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PREPARED BY

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ADVERTISEMENT.

In connection with the system of meteorological observations established by the Smithsonian Institution about 1850, a series of meteorological tables was compiled by Dr. Arnold Guyot, at the request of Secretary Henry, and the first edition was published in 1852. Though primarily designed for meteorological observers reporting to the Smithsonian Institution, the tables were so widely used by physicists that it seemed desirable to recast the work entirely. It was decided to publish three sets of tables, each representative of the latest knowledge in its field, and independent of one another, but forming a homogeneous series. The first of the new series, Meteorological Tables, was published in 1893, the second, Geographical Tables, in 1894, and the third, Physical Tables, in 1896. In 1909 yet another volume was added, so that the series now comprises: Smithsonian Meteorological Tables, Smithsonian Geographical Tables, Smithsonian Physical Tables, and Smithsonian Mathematical Tables.

The fourteen years which have elapsed since the publication of the first edition of the Physical Tables, prepared by Professor Thomas Gray, have brought such changes in the material upon which the tables must be based that it became necessary to prepare this almost wholly new set of tables for the present edition.

CHARLES D. WALCOTT,
Secretary, Smithsonian Institution.

June, 1910.

PREFACE.

The present Smithsonian Physical Tables are the outcome of a radical revision of the set of tables compiled by Professor Thomas Gray in 1896. Recent data and many new tables have been added for which the references to the sources have been made more complete; and several mathematical tables have been added, — some of them especially computed for this work. The inclusion of these mathematical tables seems warranted by the demand for them. In order to preserve a uniform change of argument and to facilitate comparison, many of the numbers given in some tables have been obtained by interpolation in the data actually given in the papers quoted.

Our gratitude is expressed for many suggestions and for help in the improvement of the present edition: to the U. S. Bureau of Standards for the revision of the electrical, magnetic, and metrological tables and other suggestions; to the U. S. Coast and Geodetic Survey for the revision of the magnetic and geodetic tables; to the U. S. Geological Survey for various data; to Mr. Van Orstrand for several of the mathematical tables; to Mr. Wead for the data on the musical scales; to Mr. Sosman for the new physical-chemistry data; to Messrs. Abbot, Becker, Lanza, Rosa, and Wood; to the U. S. Bureau of Forestry and to others. We are also under obligation to the authors and publishers of Landolt-Börnstein-Meyerhoffer's Physikalisch-chemische Tabellen (1905) and B. O. Peirce's Mathematical Tables for the use of certain tables.

It is hardly possible that any series of tables involving so much transcribing, interpolation, and calculation should be entirely free from errors, and the Smithsonian Institution will be grateful, not only for notice of whatever errors may be found, but also for suggestions as to other changes which may seem advisable for later editions.

F. E. FOWLE.

ASTROPHYSICAL OBSERVATORY
OF THE SMITHSONIAN INSTITUTION,
June, 1910

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INTRODUCTION.

UNITS OF MEASUREMENT AND CONVERSION FORMULÆ.

Units. — The quantitative measure of anything is a number which expresses the ratio of the magnitude of the thing to the magnitude of some other thing of the same kind. In order that the number expressing the measure may be intelligible, the magnitude of the thing used for comparison must be known. This leads to the conventional choice of certain magnitudes as units of measurement, and any other magnitude is then simply expressed by a number which tells how many magnitudes equal to the unit of the same kind of magnitude it contains. For example, the distance between two places may be stated as a certain number of miles or of yards or of feet. In the first case, the mile is assumed as a known distance; in the second, the yard, and in the third, the foot. What is sought for in the statement is to convey an idea of the distance by describing it in terms of distances which are either familiar or easily referred to for comparison. Similarly quantities of matter are referred to as so many tons or pounds or grains and so forth, and intervals of time as a number of hours or minutes or seconds. Generally in ordinary affairs such statements appeal to experience; but, whether this be so or not, the statement must involve some magnitude as a fundamental quantity, and this must be of such a character that, if it is not known, it can be readily referred to. We become familiar with the length of a mile by walking over distances expressed in miles, with the length of a yard or a foot by examining a yard or a foot measure and comparing it with something easily referred to, — say our own height, the length of our foot or step, — and similarly for quantities of other kinds. This leads us to be able to form a mental picture of such magnitudes when the numbers expressing them are stated, and hence to follow intelligently descriptions of the results of scientific work. The possession of copies of the units enables us by proper comparisons to find the magnitude-numbers expressing physical quantities for ourselves. The numbers descriptive of any quantity must depend on the intrinsic magnitude of the unit in terms of which it is described. Thus a mile is 1760 yards, or 5280 feet, and hence when a mile is taken as the unit the magnitude-number for the distance is 1, when a yard is taken as the unit the magnitude-number is 1760, and when a foot is taken it is 5280. Thus, to obtain the magnitude-number for a quantity in terms of a new unit when it is already known in terms of another we have to multiply the old magnitude-number by the ratio of the intrinsic values of the old and new units; that is, by the number of the new units required to make one of the old.

Fundamental Units of Length and Mass. — It is desirable that as few different kinds of unit quantities as possible should be introduced into our measurements, and since it has been found possible and convenient to express a large number of physical quantities in terms of length or mass or time units and combinations of these they have been very generally adopted as fundamental units. Two systems of such units are used in this country for scientific measurements, namely, the British, and the French or metric, systems. Tables of conversion factors are given in the book for facilitating comparisons between quantities expressed in terms of one system with similar quantities expressed in the other. In the customary system the standard unit of length is the yard and is now defined as 3600/3937 metre. The unit of mass is the avoirdupois pound and is defined as 1/2.20462 kilogramme.

The British yard is defined as the "straight line or distance (at 62° F.) between the transverse lines in the two gold plugs in the bronze bar deposited in the office of the exchequer." The British standard of mass is the pound avoirdupois and is the mass of a piece of platinum marked "P. S. 1844, 1 lb.," preserved in the exchequer office.

In the metric system the standard of length is defined as the distance between the ends of a certain platinum bar (the *mètre des Archives*) when the whole bar is at the temperature 0° Centigrade. The bar was made by Borda, and is preserved in the national archives of France. A line-standard metre has been constructed by the International Bureau of Weights and Measures, and is known as the International Prototype Metre. A number of standard-metre bars which have been carefully compared with the International Prototype have lately been made by the International Bureau of Weights and Measures and furnished to the various governments who have contributed to the support of that bureau. These copies are called National Prototypes.

Borda, Delambre, Laplace, and others, acting as a committee of the French Academy, recommended that the standard unit of length should be the ten millionth part of the length, from the equator to the pole, of the meridian passing through Paris. In 1795 the French Republic passed a decree making this the legal standard of length, and an arc of the meridian extending from Dunkirk to Barcelona was measured by Delambre and Mechain for the purpose of realizing the standard. From the results of that measurement the metre bar was made by Borda. The metre is not now defined as stated above, but as the length of Borda's rod, and hence subsequent measurements of the length of the meridian have not affected the length of the metre.

The French, or metric, standard of mass, the kilogramme, is the mass of a piece of platinum also made by Borda in accordance with the same decree of the Republic. It was connected with the standard of length by being made as nearly as possible of the same mass as that of a cubic decimetre of distilled water at the temperature of 4° C., or nearly the temperature of maximum density.

As in the case of the metre, the International Bureau of Weights and Measures has made copies of the kilogramme. One of these is taken as a standard and is called the International Prototype Kilogramme. The others were distributed in the same manner as the metre standards, and are called National Prototypes.

Comparisons of the French and customary standards are given in tabular form in Table 2; and similarly Table 3, differing slightly, compares the British and French systems. In the metric system the decimal subdivision is used, and thus we have the decimetre, the centimetre, and the millimetre as subdivisions, and the dekametre, hektometre, and kilometre as multiples. The centimetre is most commonly used in scientific work.

Time. — The unit of time in both the systems here referred to is the mean solar second, or the 86,400th part of the mean solar day. The unit of time is thus founded on the average time required for the earth to make one revolution on its axis relatively to the sun as a fixed point of reference.

Derived Units. — Units of quantities depending on powers greater than unity of the fundamental length, mass, and time units, or on combinations of different powers of these units, are called "derived units." Thus, the unit of area and of volume are respectively the area of a square whose side is the unit of length and the volume of a cube whose edge is the unit of length. Suppose that the area of a surface is expressed in terms of the foot as fundamental unit, and we wish to find the area-number when the yard is taken as fundamental unit. The yard is 3 times as long as the foot, and therefore the area of a square whose side is a yard is 3 × 3 times as great as that whose side is a foot. Thus, the surface will only make one ninth as many units of area when the yard is the unit of length as it will make when the foot is that unit. To transform, then, from the foot as old unit to the yard as new unit, we have to multiply the old area-number by 1/9, or by the ratio of the magnitude of the old to that of the new unit of area. This is the same rule as that given above, but it is usually more convenient to express the transformations in terms of the fundamental units directly. In the above case, since on the method of measurement here adopted an area-number is the product of a length-number by a length-number the ratio of two units is the square of the ratio of the intrinsic values of the two units of length. Hence, if l be the ratio of the magnitude of the old to that of the new unit of length, the ratio of the corresponding units of area is l^2. Similarly the ratio of two units of volume will be l^3, and so on for other quantities.

Dimensional Formulæ. — It is convenient to adopt symbols for the ratios of length units, mass units, and time units, and adhere to their use throughout; and in what follows, the small letters, l, m, t, will be used for these ratios. These letters will always represent simple numbers, but the magnitude of the number will depend on the relative magnitudes of the units the ratios of which they represent. When the values of the numbers represented by l, m, t are known, and the powers of l, m, and t involved in any particular unit are also known, the factor for transformation is at once obtained. Thus, in the above example, the value of l was 1/3 and the power of l involved in the expression for area is l^2; hence, the factor for transforming from square feet to square yards is 1/9. These factors have been called by Prof. James Thomson "change ratios," which seems an appropriate term. The term "conversion factor" is perhaps more generally known, and has been used throughout this book.

Conversion Factor. — In order to determine the symbolic expression for the conversion factor for any physical quantity, it is sufficient to determine the degree to which the quantities length, mass, and time are involved in the quantity. Thus, a velocity is expressed by the ratio of the number representing a length to that representing an interval of time, or L/T, an acceleration by a velocity-number divided by an interval of time-number, or L/T^2, and so on, and the corresponding ratios of units must therefore enter to precisely the same degree. The factors would thus be for the above cases, l/t and l/t^2. Equations of the form above given for velocity and acceleration which show the dimensions of the quantity in terms of the fundamental units are called "dimensional equations." Thus

$$E = ML^2T^{-2}$$

is the dimensional equation for energy, and ML^2T^{-2} is the dimensional formula for energy.

In general, if we have an equation for a physical quantity

$$Q = CL^aM^bT^c,$$

where C is a constant and LMT represents length, mass, and time in terms of one set of units, and we wish to transform to another set of units in terms of which the length, mass, and time are $L_/M_/T_/$, we have to find the value of $\frac{L_/}{L}, \frac{M_/}{M}, \frac{T_/}{T}$, which in accordance with the convention adopted above will be $l\ m\ t$, or the ratios of the magnitudes of the old to those of the new units.

Thus $L_/ = Ll$, $M_/ = Mm$, $T_/ = Tt$, and if $Q_/$ be the new quantity-number

$$\begin{aligned} Q_/ &= CL_/^aM_/^bT_/^c \\ &= CL^al^aM^bm^bT^ct^c = Ql^am^bt^c, \end{aligned}$$

or the conversion factor is $l^am^bt^c$, a quantity of precisely the same form as the dimension formula $L^aM^bT^c$.

We now proceed to form the dimensional and conversion factor formulæ for the more commonly occurring derived units.

1. **Area.** — The unit of area is the square the side of which is measured by the unit of length. The area of a surface is therefore expressed as

$$S = CL^2,$$

where C is a constant depending on the shape of the boundary of the surface and L a linear dimension. For example, if the surface be square and L be the length of a side C is unity. If the boundary be a circle and L be a diameter $C = \pi/4$, and so on. The dimensional formula is thus L^2, and the conversion factor l^2.

2. **Volume.** — The unit of volume is the volume of a cube the edge of which is measured by the unit of length. The volume of a body is therefore expressed as

$$V = CL^3,$$

where as before C is a constant depending on the shape of the boundary. The dimensional formula is L^3 and the conversion factor l^3.

3. **Density.** — The density of a substance is the quantity of matter in the unit of volume. The dimension formula is therefore M/V or ML^{-3}, and conversion factor ml^{-3}.

Example. — The density of a body is 150 in pounds per cubic foot: required the density in grains per cubic inch.

Here m is the number of grains in a pound $= 7000$, and l is the number of inches in a foot $= 12$; $\therefore ml^{-3} = 7000/12^3 = 4.051$. Hence the density is $150 \times 4.051 = 607.6$ in grains per cubic inch.

NOTE. — The specific gravity of a body is the ratio of its density to the density of a standard substance. The dimension formula and conversion factor are therefore both unity.

4. **Velocity.** — The velocity of a body at any instant is given by the equation $v = \frac{dL}{dT}$, or velocity is the ratio of a length-number to a time-number. The dimension formula is LT^{-1}, and the conversion factor lt^{-1}.

Example. — A train has a velocity of 60 miles an hour: what is its velocity in feet per second?

Here $l = 5280$ and $t = 3600$; $\therefore lt^{-1} = \frac{5280}{3600} = \frac{44}{30} = 1.467$. Hence the velocity $= 60 \times 1.467 = 88.0$ in feet per second.

5. **Angle.** — An angle is measured by the ratio of the length of an arc to the length of the radius of the arc. The dimension formula and the conversion factor are therefore both unity.

6. **Angular Velocity.** — Angular velocity is the ratio of the magnitude of the angle described in an interval of time to the length of the interval. The dimension formula is therefore T^{-1}, and the conversion factor is t^{-1}.

7. **Linear Acceleration.** — Acceleration is the rate of change of velocity or $a = \frac{dv}{dt}$. The dimension formula is therefore VT^{-1} or LT^{-2}, and the conversion factor is lt^{-2}.

Example. — A body acquires velocity at a uniform rate, and at the end of one minute is moving at the rate of 20 kilometres per hour: what is the acceleration in centimetres per second per second?

Since the velocity gained was 20 kilometres per hour in one minute, the acceleration was 1200 kilometres per hour per hour.

Here $l = 100\,000$ and $t = 3600$; $\therefore lt^{-2} = 100\,000/3600^2 = .00771$, and therefore acceleration $= .00771 \times 1200 = 9.26$ centimetres per second.

8. **Angular Acceleration.** — Angular acceleration is rate of change of angu-

lar velocity. The dimensional formula is thus $\frac{\text{angular velocity}}{\text{T}}$ or T^{-2}, and the conversion factor t^{-2}.

9. **Solid Angle.** — A solid angle is measured by the ratio of the surface of the portion of a sphere enclosed by the conical surface forming the angle to the square of radius of the spherical surface, the centre of the sphere being at the vertex of the cone. The dimensional formula is therefore $\frac{\text{area}}{\text{L}^2}$ or 1, and hence the conversion factor is also 1.

10. **Curvature.** — Curvature is measured by the rate of change of direction of the curve with reference to distance measured along the curve as independent variable. The dimension formula is therefore $\frac{\text{angle}}{\text{length}}$ or L^{-1}, and the conversion factor is l^{-1}.

11. **Tortuosity.** — Tortuosity is measured by the rate of rotation of the tangent plane round the tangent to the curve of reference when length along the curve is independent variable. The dimension formula is therefore $\frac{\text{angle}}{\text{length}}$ or L^{-1}, and the conversion factor is l^{-1}.

12. **Specific Curvature of a Surface.** — This was defined by Gauss to be, at any point of the surface, the ratio of the solid angle enclosed by a surface formed by moving a normal to the surface round the periphery of a small area containing the point, to the magnitude of the area. The dimensional formula is therefore $\frac{\text{solid angle}}{\text{surface}}$ or L^{-2}, and the conversion factor is thus l^{-2}.

13. **Momentum.** — This is quantity of motion in the Newtonian sense, and is, at any instant, measured by the product of the mass-number and the velocity-number for the body.

Thus the dimension formula is MV or MLT^{-1}, and the conversion factor mlt^{-1}.

Example. — A mass of 10 pounds is moving with a velocity of 30 feet per second: what is its momentum when the centimetre, the gramme, and the second are fundamental units?

Here $m = 453.59$, $l = 30.48$, and $t = 1$; $\therefore mlt^{-1} = 453.59 \times 30.48 = 13825$. The momentum is thus $13825 \times 10 \times 30 = 4\,147\,500$.

14. **Moment of Momentum.** — The moment of momentum of a body with reference to a point is the product of its momentum-number and the number expressing the distance of its line of motion from the point. The dimensional formula is thus ML^2T^{-1}, and hence the conversion factor is ml^2t^{-1}.

15. **Moment of Inertia.** — The moment of inertia of a body round any axis is expressed by the formula Σmr^2, where m is the mass of any particle of the body

and r its distance from the axis. The dimension formula for the sum is clearly the same as for each element, and hence is ML^2. The conversion factor is therefore ml^2.

16. **Angular Momentum.** — The angular momentum of a body round any axis is the product of the numbers expressing the moment of inertia and the angular velocity of the body. The dimensional formula and the conversion factor are therefore the same as for moment of momentum given above.

17. **Force.** — A force is measured by the rate of change of momentum it is capable of producing. The dimension formulæ for force and "time rate of change of momentum" are therefore the same, and are expressed by the ratio of momentum-number to time-number or MLT^{-2}. The conversion factor is thus mlt^{-2}.

NOTE. — When mass is expressed in pounds, length in feet, and time in seconds, the unit force is called the poundal. When grammes, centimetres, and seconds are the corresponding units the unit of force is called the dyne.

Example. Find the number of dynes in 25 poundals.

Here $m = 453.59$, $l = 30.48$, and $t = 1$; $\therefore mlt^{-2} = 453.59 \times 30.48 = 13825$ nearly. The number of dynes is thus $13825 \times 25 = 345625$ approximately.

18. **Moment of a Couple, Torque, or Twisting Motive.** — These are different names for a quantity which can be expressed as the product of two numbers representing a force and a length. The dimension formula is therefore FL or ML^2T^{-2}, and the conversion factor is ml^2t^{-2}.

19. **Intensity of a Stress.** — The intensity of a stress is the ratio of the number expressing the total stress to the number expressing the area over which the stress is distributed. The dimensional formula is thus FL^{-2} or $ML^{-1}T^{-2}$, and the conversion factor is $ml^{-1}t^{-2}$.

20. **Intensity of Attraction, or "Force at a Point."** — This is the force of attraction per unit mass on a body placed at the point, and the dimensional formula is therefore FM^{-1} or LT^{-2}, the same as acceleration. The conversion factors for acceleration therefore apply.

21. **Absolute Force of a Centre of Attraction, or "Strength of a Centre."** — This is the intensity of force at unit distance from the centre, and is therefore the force per unit mass at any point multiplied by the square of the distance from the centre. The dimensional formula thus becomes FL^2M^{-1} or L^3T^{-2}. The conversion factor is therefore l^3t^{-2}.

22. **Modulus of Elasticity.** — A modulus of elasticity is the ratio of stress intensity to percentage strain. The dimension of percentage strain is a length divided by a length, and is therefore unity. Hence, the dimensional formula of a modulus of elasticity is the same as that of stress intensity, or $ML^{-1}T^{-2}$, and the conversion factor is thus also $ml^{-1}t^{-2}$.

23. **Work and Energy.** — When the point of application of a force, acting on a body, moves in the direction of the force, work is done by the force, and the amount is measured by the product of the force and displacement numbers. The dimensional formula is therefore FL or ML^2T^{-2}.

The work done by the force either produces a change in the velocity of the body or a change of shape or configuration of the body, or both. In the first case it produces a change of kinetic energy, in the second a change of potential energy. The dimension formulæ of energy and work, representing quantities of the same kind, are identical, and the conversion factor for both is ml^2t^{-2}.

24. **Resilience.** — This is the work done per unit volume of a body in distorting it to the elastic limit or in producing rupture. The dimension formula is therefore $ML^2T^{-2}L^{-3}$ or $ML^{-1}T^{-2}$, and the conversion factor $ml^{-1}t^{-2}$.

25. **Power, or Activity.** — Power — or, as it is now very commonly called, activity — is defined as the time rate of doing work, or if W represent work and P power $P = \frac{dw}{dt}$. The dimensional formula is therefore WT^{-1} or ML^2T^{-3}, and the conversion factor ml^2t^{-3}, or for problems in gravitation units more conveniently flt^{-1}, where f stands for the force factor.

Examples. (*a*) Find the number of gramme centimetres in one foot pound.

Here the units of force are the attraction of the earth on the pound* and the gramme of matter, and the conversion factor is fl, where f is 453.59 and l is 30.48.

Hence the number is $453.59 \times 30.48 = 13825$.

(*b*) Find the number of foot poundals in 1 000000 centimetre dynes.

Here $m = 1/453.59$, $l = 1/30.48$, and $t = 1$; $\therefore\ ml^2t^{-2} = 1/453.59 \times 30.48^2$, and $10^6ml^2t^{-2} = 10^6/453.59 \times 30.48^2 = 2.373$.

(*c*) If gravity produces an acceleration of 32.2 feet per second per second, how many watts are required to make one horse-power?

One horse-power is 550 foot pounds per second, or $550 \times 32.2 = 17710$ foot poundals per second. One watt is 10^7 ergs per second, that is, 10^7 dyne centimetres per second. The conversion factor is ml^2t^{-3}, where $m = 453.59$, $l = 30.48$, and $t = 1$, and the result has to be divided by 10^7, the number of dyne centimetres per second in the watt.

Hence, $17710\, ml^2t^{-3}/10^7 = 17710 \times 453.59 \times 30.48^2/10^7 = 746.3$.

(*d*) How many gramme centimetres per second correspond to 33000 foot pounds per minute?

The conversion factor suitable for this case is flt^{-1}, where f is 453.59, l is 30.48, and t is 60.

Hence, $33000\, lt^{-1} = 33000 \times 453.59 \times 30.48/60 = 7\,604\,000$ nearly.

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* It is important to remember that in problems like that here given the term "pound" or "gramme" refers to force and not to mass.

HEAT UNITS.

1. If heat be measured in dynamical units its dimensions are the same as those of energy, namely ML^2T^{-2}. The most common measurements, however, are made in thermal units, that is, in terms of the amount of heat required to raise the temperature of unit mass of water one degree of temperature at some stated temperature. This method of measurement involves the unit of mass and some unit of temperature; and hence, if we denote temperature-numbers by Θ and their conversion factors by θ, the dimensional formula and conversion factor for quantity of heat will be $M\Theta$ and $m\theta$ respectively. The relative amount of heat compared with water as standard substance required to raise unit mass of different substances one degree in temperature is called their specific heat, and is a simple number.

Unit volume is sometimes used instead of unit mass in the measurement of heat, the units being then called thermometric units. The dimensional formula is in that case changed by the substitution of volume for mass, and becomes $L^3\Theta$, and hence the conversion factor is to be calculated from the formula $l^3\theta$.

For other physical quantities involving heat we have:—

2. **Coefficient of Expansion.**—The coefficient of expansion of a substance is equal to the ratio of the change of length per unit length (linear), or change of volume per unit volume (voluminal) to the change of temperature. These ratios are simple numbers, and the change of temperature is inversely as the magnitude of the unit of temperature. Hence the dimensional and conversion-factor formulæ are Θ^{-1} and θ^{-1}.

3. **Conductivity, or Specific Conductance.**—This is the quantity of heat transmitted per unit of time per unit of surface per unit of temperature gradient. The equation for conductivity is therefore, with H as quantity of heat,

$$K = \frac{H}{\frac{\Theta}{L} L^2 T}$$

and the dimensional formula $\frac{H}{\Theta LT} = \frac{M}{LT}$, which gives $ml^{-1}t^{-1}$ for conversion factor.

In thermometric units the formula becomes L^2T^{-1}, which properly represents diffusivity. In dynamical units H becomes ML^2T^{-2}, and the formula changes to $MLT^{-3}\Theta^{-1}$. The conversion factors obtained from these are l^2t^{-1} and $mlt^{-3}\theta^{-1}$ respectively.

4. **Thermal Capacity.** — This is the product of the number for mass and the specific heat, and hence the dimensional formula and conversion factor are simply M and *m*.

5. **Latent Heat.** — Latent heat is the ratio of the number representing the quantity of heat required to change the state of a body to the number representing the quantity of matter in the body. The dimensional formula is therefore $M\Theta/M$ or Θ, and hence the conversion factor is simply the ratio of the temperature units or θ. In dynamical units the factor is l^2t^{-2}.*

6. **Joule's Equivalent.** — Joule's dynamical equivalent is connected with quantity of heat by the equation

$$ML^2T^{-2} = JH \text{ or } JM\Theta.$$

This gives for the dimensional formula of J the expression $L^2T^{-2}\Theta^{-1}$. The conversion factor is thus represented by $l^2t^{-2}\theta^{-1}$. When heat is measured in dynamical units J is a simple number.

7. **Entropy.** — The entropy of a body is directly proportional to the quantity of heat it contains and inversely proportional to its temperature. The dimensional formula is thus $M\Theta/\Theta$ or M, and the conversion factor is *m*. When heat is measured in dynamical units the factor is $ml^2t^{-2}\theta^{-1}$.

Examples. (*a*) Find the relation between the British thermal unit, the calorie, and the therm.

Neglecting the variation of the specific heat of water with temperature, or defining all the units for the same temperature of the standard substance, we have the following definitions. The *British thermal unit* is the quantity of heat required to raise the temperature of one pound of water 1° F. The *calorie* is the quantity of heat required to raise the temperature of one kilogramme of water 1° C. The *therm* is the quantity of heat required to raise the temperature of one gramme of water 1° C. Hence: —

(1) To find the number of calories in one British thermal unit, we have $m = .45399$ and $\theta = \frac{5}{9}$; $\therefore m\theta = .45399 \times 5/9 = .25199$.

(2) To find the number of therms in one calorie, $m = 1000$ and $\theta = 1$; $\therefore m\theta = 1000$.

It follows at once that the number of therms in one British thermal unit is $1000 \times .25199 = 251.99$.

(*b*) What is the relation between the foot grain second Fahrenheit-degree and the centimetre gramme second Centigrade-degree units of conductivity?

The number of the latter units in one of the former is given by the for-

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* It will be noticed that when Θ is given the dimension formula L^2T^{-2} the formulæ in thermal and dynamical units are always identical. The thermometric units practically suppress mass.

mula $ml^{-1}t^{-1}\theta^{\circ}$, where $m=.064799$, $l=30.48$, and $t=1$, and is therefore $=$ $.064799/30.48=2.126\times10^{-8}$.

(*c*) Find the relation between the units stated in (*b*) for emissivity.

In this case the conversion formula is $ml^{-2}t^{-1}$, where ml and t have the same value as before. Hence the number of the latter units in the former is $0.064799/30.48^2=6.975\times10^{-5}$.

(*d*) Find the number of centimetre gramme second units in the inch grain hour unit of emissivity.

Here the formula is $ml^{-2}t^{-1}$, where $m=0.064799$, $l=2.54$, and $t=3600$. Therefore the required number is $0.064799/2.54^2\times3600=2.790\times10^{-6}$.

(*e*) If Joule's equivalent be 776 foot pounds per pound of water per degree Fahrenheit, what will be its value in gravitation units when the metre, the kilogramme, and the degree Centigrade are units?

The conversion factor in this case is $\frac{l^2t^{-2}\theta^{-1}}{lt^{-2}}$ or $l\theta^{-1}$, where $l=.3048$ and $\theta^{-1}=1.8$; $\therefore\ 776\times.3048\times1.8=425.7$.

(*f*) If Joule's equivalent be 24832 foot poundals when the degree Fahrenheit is unit of temperature, what will be its value when kilogramme metre second and degree-Centigrade units are used?

The conversion factor is $l^2t^{-2}\theta^{-1}$, where $l=.3048$, $t=1$, and $\theta^{-1}=1.8$; $\therefore\ 24832\times l^2t^{-2}\theta^{-1}=24832\times.3048^2\times1.8=4152.5$.

In gravitation units this would give $4152.5/9.81=423.3$.

ELECTRIC AND MAGNETIC UNITS.

There are two systems of these units, the electrostatic and the electromagnetic systems, which differ from each other because of the different fundamental suppositions on which they are based. In the electrostatic system the repulsive force between two quantities of static electricity is made the basis. This connects force, quantity of electricity, and length by the equation $f=a\frac{qq_{\prime}}{l^2}$, where f is force, a a quantity depending on the units employed and on the nature of the medium, q and $q_{\prime}$ quantities of electricity, and l the distance between q and $q_{\prime}$. The magnitude of the force f for any particular values of $q, q_{\prime}$ and l depends on a property of the medium across which the force takes place called its inductive capacity. The inductive capacity of air has generally been assumed as unity, and the inductive capacity of other media expressed as a number representing the ratio of the inductive capacity of the medium to that of air. These numbers are known as the specific inductive capacities of the media. According to the ordinary assumption, then, of air as the standard medium, we obtain unit quantity of electricity when in the above equation $q=q_{\prime}$, and f, a, and l are each unity. A formal definition is given below.

In the electromagnetic system the repulsion between two magnetic poles or quantities of magnetism is taken as the basis. In this system the quantities force, quantity of magnetism, and length are connected by an equation of the form

$$f = a\frac{mm_l}{l^2},$$

where m and m_l are in this case quantities of magnetism, and the other symbols have the same meaning as before. In this case it has been usual to assume the magnetic inductive capacity of air to be unity, and to express the magnetic inductive capacity of other media as a simple number representing the ratio of the inductive capacity of the medium to that of air. These numbers, by analogy with specific inductive capacity for electricity, might be called specific inductive capacities for magnetism. They are usually called permeabilities. (*Vide* Thomson, "Papers on Electrostatics and Magnetism," p. 484.) In this case, also, like that for electricity, the unit quantity of magnetism is obtained by making $m = m_l$, and f, a, and l each unity.

In both these cases the intrinsic inductive capacity of the standard medium is suppressed, and hence also that of all other media. Whether this be done or not, direct experiment has to be resorted to for the determination of the absolute values of the units and the relations of the units in the one system to those in the other. The character of this relation can be directly inferred from the dimensional formulæ of the different quantities, but these can give no information as to the relative absolute values of the units in the two systems. Prof. Rücker has suggested (Phil. Mag. vol. 27) the advisability of at least indicating the existence of the suppressed properties by putting symbols for them in the dimensional formulæ. This has the advantage of showing how the magnitudes of the different units would be affected by a change in the standard medium, or by making the standard medium different for the two systems. In accordance with this idea, the symbols K and P have been introduced into the formulæ given below to represent inductive capacity in the electrostatic and the electromagnetic systems respectively. In the conversion formulæ k and p are the ordinary specific inductive capacities and permeabilities of the media when air is taken as the standard, or generally those with reference to the first medium taken as standard. The ordinary formulæ may be obtained by putting K and P equal to unity.

ELECTROSTATIC UNITS.

1. **Quantity of Electricity.** — The unit quantity of electricity is defined as that quantity which if concentrated at a point and placed at unit distance from an equal and similarly concentrated quantity repels it, or is repelled by it, with unit force. The medium or dielectric is usually taken as air, and the other units in accordance with the centimetre gramme second system.

In this case we have the force of repulsion proportional directly to the square of the quantity of electricity and inversely to the square of the distance between the quantities and to the inductive capacity. The dimensional formula is therefore the same as that for $[\text{force} \times \text{length}^2 \times \text{inductive capacity}]^{\frac{1}{2}}$ or $M^{\frac{1}{2}}L^{\frac{3}{2}}T^{-1}K^{\frac{1}{2}}$, and the conversion factor is $m^{\frac{1}{2}}l^{\frac{3}{2}}t^{-1}k^{\frac{1}{2}}$.

2. **Electric Surface Density and Electric Displacement.** — The density of an electric distribution at any point on a surface is measured by the quantity per unit of area, and the electric displacement at any point in a dielectric is measured by the quantity displaced per unit of area. These quantities have therefore the same dimensional formula, namely, the ratio of the formulæ for quantity of electricity and for area or $M^{\frac{1}{2}}L^{-\frac{1}{2}}T^{-1}K^{\frac{1}{2}}$, and the conversion factor $m^{\frac{1}{2}}l^{-\frac{1}{2}}t^{-1}k^{\frac{1}{2}}$.

3. **Electric Force at a Point, or Intensity of Electric Field.** — This is measured by the ratio of the magnitude of the force on a quantity of electricity at a point to the magnitude of the quantity of electricity. The dimensional formula is therefore the ratio of the formulæ for force and electric quantity, or

$$\frac{MLT^{-2}}{M^{\frac{1}{2}}L^{\frac{3}{2}}T^{-1}K^{\frac{1}{2}}}=M^{\frac{1}{2}}L^{-\frac{1}{2}}T^{-1}K^{-\frac{1}{2}},$$

which gives the conversion factor $m^{\frac{1}{2}}l^{-\frac{1}{2}}t^{-1}k^{-\frac{1}{2}}$.

4. **Electric Potential and Electromotive Force.** — Change of potential is proportional to the work done per unit of electricity in producing the change. The dimensional formula is therefore the ratio of the formulæ for work and electric quantity, or

$$\frac{ML^{2}T^{-2}}{M^{\frac{1}{2}}L^{\frac{3}{2}}T^{-1}K^{\frac{1}{2}}}=M^{\frac{1}{2}}L^{\frac{1}{2}}T^{-1}K^{-\frac{1}{2}},$$

which gives the conversion factor $m^{\frac{1}{2}}l^{\frac{1}{2}}t^{-1}k^{-\frac{1}{2}}$.

5. **Capacity of a Conductor.** — The capacity of an insulated conductor is proportional to the ratio of the numbers representing the quantity of electricity in a charge and the potential of the charge. The dimensional formula is thus the ratio of the two formulæ for electric quantity and potential, or

$$\frac{M^{\frac{1}{2}}L^{\frac{3}{2}}T^{-1}K^{\frac{1}{2}}}{M^{\frac{1}{2}}L^{\frac{1}{2}}T^{-1}K^{-\frac{1}{2}}}=LK,$$

which gives lk for conversion factor. When K is taken as unity, as in the ordinary units, the capacity of an insulated conductor is simply a length.

6. **Specific Inductive Capacity.** — This is the ratio of the inductive capacity of the substance to that of a standard substance, and hence the dimensional formula is K/K or 1.*

7. **Electric Current.** — Current is quantity flowing past a point per unit of time. The dimensional formula is thus the ratio of the formulæ for electric quantity and for time, or,

$$\frac{M^{\frac{1}{2}}L^{\frac{3}{2}}T^{-1}K^{\frac{1}{2}}}{T}=M^{\frac{1}{2}}L^{\frac{3}{2}}T^{-2}K^{\frac{1}{2}},$$

and the conversion factor $m^{\frac{1}{2}}l^{\frac{3}{2}}t^{-2}k^{\frac{1}{2}}$.

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* According to the ordinary definition referred to air as standard medium, the specific inductive capacity of a substance is K, or is identical in dimensions with what is here taken as inductive capacity. Hence in that case the conversion factor must be taken as 1 on the electrostatic and as $l^{-2}t^{2}$ on the electromagnetic system.

8. **Conductivity, or Specific* Conductance.** — This, like the corresponding term for heat, is quantity per unit area per unit potential gradient per unit of time. The dimensional formula is therefore

$$\frac{M^{\frac{1}{2}}L^{\frac{3}{2}}T^{-1}K^{\frac{1}{2}}}{L^2\dfrac{M^{\frac{1}{2}}L^{\frac{1}{2}}T^{-1}K^{-\frac{1}{2}}}{L}T} = T^{-1}K, \text{ or } \frac{\text{electric quantity}}{\text{area} \times \text{potential gradient} \times \text{time}}.$$

The conversion factor is $t^{-1}k$.

9. **Specific* Resistance.** — This is the reciprocal of conductivity as above defined, and hence the dimensional formula and conversion factor are respectively TK^{-1} and tk^{-1}.

10. **Conductance.** — The conductance of any part of an electric circuit, not containing a source of electromotive force, is the ratio of the numbers representing the current flowing through it and the difference of potential between its ends. The dimensional formula is thus the ratio of the formulæ for current and potential, or

$$\frac{M^{\frac{1}{2}}L^{\frac{3}{2}}T^{-2}K^{\frac{1}{2}}}{M^{\frac{1}{2}}L^{\frac{1}{2}}T^{-1}K^{-\frac{1}{2}}} = LT^{-1}K,$$

from which we get the conversion factor $lt^{-1}k$.

11. **Resistance.**—This is the reciprocal of conductance, and therefore the dimensional formula and the conversion factor are respectively $L^{-1}TK^{-1}$ and $l^{-1}tk^{-1}$.

EXAMPLES OF CONVERSION IN ELECTROSTATIC UNITS.

(*a*) Find the factor for converting quantity of electricity expressed in foot grain second units to the same expressed in c. g. s. units.

By (1) the formula is $m^{\frac{1}{2}}l^{\frac{3}{2}}t^{-1}k^{\frac{1}{2}}$, in which in this case $m = 0.0648$, $l = 30.48$, $t = 1$, and $k = 1$; $\therefore$ the factor is $0.0648^{\frac{1}{2}} \times 30.48^{\frac{3}{2}} = 4.2836$.

(*b*) Find the factor required to convert electric potential from millimetre milligramme second units to c. g. s. units.

By (4) the formula is $m^{\frac{1}{2}}l^{\frac{1}{2}}t^{-1}k^{-\frac{1}{2}}$, and in this case $m = 0.001$, $l = 0.1$, $t = 1$, and $k = 1$; $\therefore$ the factor $= 0.001^{\frac{1}{2}} \times 0.1^{\frac{1}{2}} = 0.01$.

(*c*) Find the factor required to convert from foot grain second and specific inductive capacity 6 units to c. g. s. units.

By (5) the formula is lk, and in this case $l = 30.48$ and $k = 6$; $\therefore$ the factor $= 30.48 \times 6 = 182.88$.

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* The term "specific," as used here and in 9, refers conductance and resistance to that between the ends of a bar of unit section and unit length, and hence is different from the same term in specific heat, specific inductivity, capacity, etc., which refer to a standard substance.

ELECTROMAGNETIC UNITS.

As stated above, these units bear the same relation to unit quantity of magnetism that the electric units do to quantity of electricity. Thus, when inductive capacity is suppressed, the dimensional formula for magnetic quantity on this system is the same as that for electric quantity on the electrostatic system. All quantities in this system which only differ from corresponding quantities defined above by the substitution of magnetic for electric quantity may have their dimensional formulæ derived from those of the corresponding quantity by substituting P for K.

1. **Magnetic Pole, or Quantity of Magnetism.** — Two unit quantities of magnetism concentrated at points unit distance apart repel each other with unit force. The dimensional formula is thus the same as for [force × length^2 × inductive capacity] or $M^{\frac{1}{2}}L^{\frac{3}{2}}T^{-1}P^{\frac{1}{2}}$, and the conversion factor is $m^{\frac{1}{2}}l^{\frac{3}{2}}t^{-1}p^{\frac{1}{2}}$.

2. **Density of Surface Distribution of Magnetism.** — This is measured by quantity of magnetism per unit area, and the dimension formula is therefore the ratio of the expressions for magnetic quantity and for area, or $M^{\frac{1}{2}}L^{-\frac{1}{2}}T^{-1}P^{\frac{1}{2}}$, which gives the conversion factor $m^{\frac{1}{2}}l^{-\frac{1}{2}}t^{-1}p^{\frac{1}{2}}$.

3. **Magnetic Force at a Point, or Intensity of Magnetic Field.** — The number for this is the ratio of the numbers representing the magnitudes of the force on a magnetic pole placed at the point and the magnitude of the magnetic pole.

The dimensional formula is therefore the ratio of the expressions for force and magnetic quantity, or

$$\frac{MLT^{-2}}{M^{\frac{1}{2}}L^{\frac{3}{2}}T^{-1}P^{\frac{1}{2}}} = M^{\frac{1}{2}}L^{-\frac{1}{2}}T^{-1}P^{-\frac{1}{2}},$$

and the conversion factor $m^{\frac{1}{2}}l^{-\frac{1}{2}}t^{-1}p^{-\frac{1}{2}}$.

4. **Magnetic Potential.** — The magnetic potential at a point is measured by the work which is required to bring unit quantity of positive magnetism from zero potential to the point. The dimensional formula is thus the ratio of the formula for work and magnetic quantity, or

$$\frac{ML^2T^{-2}}{M^{\frac{1}{2}}L^{\frac{3}{2}}T^{-1}P^{\frac{1}{2}}} = M^{\frac{1}{2}}L^{\frac{1}{2}}T^{-1}P^{-\frac{1}{2}},$$

which gives the conversion factor $m^{\frac{1}{2}}l^{\frac{1}{2}}t^{-1}p^{-\frac{1}{2}}$.

5. **Magnetic Moment.** — This is the product of the numbers for pole strength and length of a magnet. The dimensional formula is therefore the product of the formulæ for magnetic quantity and length, or $M^{\frac{1}{2}}L^{\frac{5}{2}}T^{-1}P^{\frac{1}{2}}$, and the conversion factor $m^{\frac{1}{2}}l^{\frac{5}{2}}t^{-1}p^{\frac{1}{2}}$.

6. **Intensity of Magnetization.** — The intensity of magnetization of any portion of a magnetized body is the ratio of the numbers representing the magni-

tude of the magnetic moment of that portion and its volume. The dimensional formula is therefore the ratio of the formulæ for magnetic moment and volume, or

$$\frac{M^{\frac{1}{2}}L^{\frac{5}{2}}T^{-1}P^{\frac{1}{2}}}{L^{3}} = M^{\frac{1}{2}}L^{-\frac{1}{2}}T^{-1}P^{\frac{1}{2}}.$$

The conversion factor is therefore $m^{\frac{1}{2}}l^{-\frac{1}{2}}t^{-1}p^{\frac{1}{2}}$.

7. **Magnetic Permeability,* or Specific Magnetic Inductive Capacity.** — This is the analogue in magnetism to specific inductive capacity in electricity. It is the ratio of the magnetic induction in the substance to the magnetic induction in the field which produces the magnetization, and therefore its dimensional formula and conversion factor are unity.

8. **Magnetic Susceptibility.** — This is the ratio of the numbers which represent the values of the intensity of magnetization produced and the intensity of the magnetic field producing it. The dimensional formula is therefore the ratio of the formulæ for intensity of magnetization and magnetic field or

$$\frac{M^{\frac{1}{2}}L^{-\frac{1}{2}}T^{-1}P^{\frac{1}{2}}}{M^{\frac{1}{2}}L^{-\frac{1}{2}}T^{-1}P^{-\frac{1}{2}}} \text{ or } P.$$

The conversion factor is therefore p, and both the dimensional formula and conversion factor are unity in the ordinary system.

9. **Current Strength.** — A current of strength c flowing round a circle of radius r produces a magnetic field at the centre of intensity $2\pi c/r$. The dimensional formula is therefore the product of the formulæ for magnetic field intensity and length, or $M^{\frac{1}{2}}L^{\frac{1}{2}}T^{-1}P^{-\frac{1}{2}}$, which gives the conversion factor $m^{\frac{1}{2}}l^{\frac{1}{2}}t^{-1}p^{-\frac{1}{2}}$.

10. **Current Density, or Strength of Current at a Point.** — This is the ratio of the numbers for current strength and area. The dimensional formula and the conversion factor are therefore $M^{\frac{1}{2}}L^{-\frac{3}{2}}T^{-1}P^{-\frac{1}{2}}$ and $m^{\frac{1}{2}}l^{-\frac{3}{2}}t^{-1}p^{-\frac{1}{2}}$.

11. **Quantity of Electricity.** — This is the product of the numbers for current and time. The dimensional formula is therefore $M^{\frac{1}{2}}L^{\frac{1}{2}}T^{-1}P^{-\frac{1}{2}} \times T = M^{\frac{1}{2}}L^{\frac{1}{2}}P^{-\frac{1}{2}}$, and the conversion factor $m^{\frac{1}{2}}l^{\frac{1}{2}}p^{-\frac{1}{2}}$.

12. **Electric Potential, or Electromotive Force.** — As in the electrostatic system, this is the ratio of the numbers for work and quantity of electricity. The dimensional formula is therefore

$$\frac{ML^{2}T^{-2}}{M^{\frac{1}{2}}L^{\frac{1}{2}}P^{-\frac{1}{2}}} = M^{\frac{1}{2}}L^{\frac{3}{2}}T^{-2}P^{\frac{1}{2}},$$

and the conversion factor $m^{\frac{1}{2}}l^{\frac{3}{2}}t^{-2}p^{\frac{1}{2}}$.

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* Permeability, as ordinarily taken with the standard medium as unity, has the same dimension formula and conversion factor as that which is here taken as magnetic inductive capacity. Hence for ordinary transformations the conversion factor should be taken as 1 in the electromagnetic and $l^{-2}t^{2}$ in the electrostatic systems.

13. **Electrostatic Capacity.** — This is the ratio of the numbers for quantity of electricity and difference of potential. The dimensional formula is therefore

$$\frac{M^{\frac{1}{2}}L^{\frac{1}{2}}P^{-\frac{1}{2}}}{M^{\frac{1}{2}}L^{\frac{3}{2}}T^{-2}P^{\frac{1}{2}}}=L^{-1}T^{2}P^{-1},$$

and the conversion factor $l^{-1}t^{2}p^{-1}$.

14. **Resistance of a Conductor.** — The resistance of a conductor or electrode is the ratio of the numbers for difference of potential between its ends and the constant current it is capable of producing. The dimensional formula is therefore the ratio of those for potential and current or

$$\frac{M^{\frac{1}{2}}L^{\frac{3}{2}}T^{-2}P^{\frac{1}{2}}}{M^{\frac{1}{2}}L^{\frac{1}{2}}T^{-1}P^{-\frac{1}{2}}}=LT^{-1}P.$$

The conversion factor thus becomes $lt^{-1}p$, and in the ordinary system resistance has the same conversion factor as velocity.

15. **Conductance.** — This is the reciprocal of resistance, and hence the dimensional formula and conversion factor are respectively $L^{-1}TP^{-1}$ and $l^{-1}tp^{-1}$.

16. **Conductivity, or Specific Conductance.** — This is quantity of electricity transmitted per unit of area per unit of potential gradient per unit of time. The dimensional formula is therefore derived from those of the quantities mentioned as follows: —

$$\frac{M^{\frac{1}{2}}L^{\frac{1}{2}}P^{-\frac{1}{2}}}{L^{2}\dfrac{M^{\frac{1}{2}}L^{\frac{3}{2}}T^{-2}P^{\frac{1}{2}}}{L}T}=L^{-2}TP^{-1}.$$

The conversion factor is therefore $l^{-2}tp^{-1}$.

17. **Specific Resistance.** — This is the reciprocal of conductivity as defined in 16, and hence the dimensional formula and conversion factor are respectively $L^{2}T^{-1}P$ and $l^{2}t^{-1}p$.

18. **Coefficient of Self-Induction, or Inductance, or Electro-kinetic Inertia.** — These are for any circuit the electromotive force produced in it by unit rate of variation of the current through it. The dimensional formula is therefore the product of the formulæ for electromotive force and time divided by that for current or

$$\frac{M^{\frac{1}{2}}L^{\frac{3}{2}}T^{-2}P^{\frac{1}{2}}}{M^{\frac{1}{2}}L^{\frac{1}{2}}T^{-1}P^{-\frac{1}{2}}}\times T=LP.$$

The conversion factor is therefore lp, and in the ordinary system is the same as that for length.

19. **Coefficient of Mutual Induction.** — The mutual induction of two circuits is the electromotive force produced in one per unit rate of variation of the current in the other. The dimensional formula and the conversion factor are therefore the same as those for self-induction.

20. **Electro-kinetic Momentum.**—The number for this is the product of the numbers for current and for electro-kinetic inertia. The dimensional formula is therefore the product of the formulæ for these quantities, or $M^{\frac{1}{2}}L^{\frac{1}{2}}T^{-1}P^{-\frac{1}{2}} \times LP = M^{\frac{1}{2}}L^{\frac{3}{2}}T^{-1}P^{\frac{1}{2}}$, and the conversion factor is $m^{\frac{1}{2}}l^{\frac{3}{2}}t^{-1}p^{\frac{1}{2}}$.

21. **Electromotive Force at a Point.**—The number for this quantity is the ratio of the numbers for electric potential or electromotive force as given in 12, and for length. The dimensional formula is therefore $M^{\frac{1}{2}}L^{\frac{1}{2}}T^{-2}P^{\frac{1}{2}}$, and the conversion factor $m^{\frac{1}{2}}l^{\frac{1}{2}}t^{-2}p^{\frac{1}{2}}$.

22. **Vector Potential.**—This is time integral of electromotive force at a point, or the electro-kinetic momentum at a point. The dimensional formula may therefore be derived from 21 by multiplying by T, or from 20 by dividing by L. It is therefore $M^{\frac{1}{2}}L^{\frac{1}{2}}T^{-1}P^{\frac{1}{2}}$, and the conversion factor $m^{\frac{1}{2}}l^{\frac{1}{2}}t^{-1}p^{\frac{1}{2}}$.

23. **Thermoelectric Height.**—This is measured by the ratio of the numbers for electromotive force and for temperature. The dimensional formula is therefore the ratio of the formulæ for these two quantities, or $M^{\frac{1}{2}}L^{\frac{3}{2}}T^{-2}P^{\frac{1}{2}}\Theta^{-1}$, and the conversion factor $m^{\frac{1}{2}}l^{\frac{3}{2}}t^{-2}p^{\frac{1}{2}}\theta^{-1}$.

24. **Specific Heat of Electricity.**—This quantity is measured in the same way as 23, and hence has the same formulæ.

25. **Coefficient of Peltier Effect.**—This is measured by the ratio of the numbers for quantity of heat and for quantity of electricity. The dimensional formula is therefore

$$\frac{M\Theta}{M^{\frac{1}{2}}L^{\frac{1}{2}}P^{-\frac{1}{2}}} = M^{\frac{1}{2}}L^{-\frac{1}{2}}P^{\frac{1}{2}}\Theta,$$

and the conversion factor $m^{\frac{1}{2}}l^{-\frac{1}{2}}p^{\frac{1}{2}}\theta$.

EXAMPLES OF CONVERSION IN ELECTROMAGNETIC UNITS.

(*a*) Find the factor required to convert intensity of magnetic field from foot grain minute units to c. g. s. units.

By (3) the formula is $m^{\frac{1}{2}}l^{-\frac{1}{2}}t^{-1}p^{-\frac{1}{2}}$, and in this case $m = 0.0648$, $l = 30.48$, $t = 60$, and $p = 1$; $\therefore$ the factors $= 0.0648^{\frac{1}{2}} \times 30.48^{-\frac{1}{2}} \times 60^{-1} = 0.00076847$.

Similarly to convert from foot grain second units to c. g. s. units the factor is $0.0648^{\frac{1}{2}} \times 30.48^{-\frac{1}{2}} = 0.046108$.

(*b*) How many c. g. s. units of magnetic moment make one foot grain second unit of the same quantity?

By (5) the formula is $m^{\frac{1}{2}}l^{\frac{5}{2}}t^{-1}p^{\frac{1}{2}}$, and the values for this problem are $m = 0.0648$, $l = 30.48$, $t = 1$, and $p = 1$; $\therefore$ the number $= 0.0648^{\frac{1}{2}} \times 30.48^{\frac{5}{2}} = 1305.6$.

(*c*) If the intensity of magnetization of a steel bar be 700 in c. g. s. units, what will it be in millimetre milligramme second units?

By (6) the formula is $m^{\frac{1}{2}}l^{\frac{1}{2}}t^{-1}p^{\frac{1}{2}}$, and in this case $m = 1000$, $l = 10$, $t = 1$, and $p = 1$; $\therefore$ the intensity $= 700 \times 1000^{\frac{1}{2}} \times 10^{\frac{1}{2}} = 70000$.

(*d*) Find the factor required to convert current strength from c. g. s. units to earth quadrant 10^{-11} gramme and second units.

By (9) the formula is $m^{\frac{1}{2}}l^{\frac{1}{2}}t^{-1}p^{-\frac{1}{2}}$, and the values of these quantities are here $m = 10^{11}$, $l = 10^{-9}$, $t = 1$, and $p = 1$; $\therefore$ the factor $= 10^{\frac{11}{2}} \times 10^{-\frac{9}{2}} = 10$.

(*e*) Find the factor required to convert resistance expressed in c. g. s. units into the same expressed in earth-quadrant 10^{-11} grammes and second units.

By (14) the formula is $lt^{-1}p$, and for this case $l = 10^{-9}$, $t = 1$, and $p = 1$; $\therefore$ the factor $= 10^{-9}$.

(*f*) Find the factor required to convert electromotive force from earth-quadrant 10^{-11} gramme and second units to c. g. s. units.

By (12) the formula is $m^{\frac{1}{2}}l^{\frac{3}{2}}t^{-2}p^{\frac{1}{2}}$, and for this case $m = 10^{-11}$, $l = 10^{9}$, $t = 1$, and $p = 1$; $\therefore$ the factor $= 10^{8}$.

PRACTICAL UNITS.

In practical electrical measurements the units adopted are either multiples or submultiples of the units founded on the centimetre, the gramme, and the second as fundamental units, and air is taken as the standard medium, for which K and P are assumed unity. The following, quoted from the report to the Honorable the Secretary of State, under date of November 6th, 1893, by the delegates representing the United States, gives the ordinary units with their names and values as defined by the International Congress at Chicago in 1893: —

"*Resolved*, That the several governments represented by the delegates of this International Congress of Electricians be, and they are hereby, recommended to formally adopt as legal units of electrical measure the following: As a unit of resistance, the *international ohm*, which is based upon the ohm equal to 10^9 units of resistance of the C. G. S. system of electro-magnetic units, and is represented by the resistance offered to an unvarying electric current by a column of mercury at the temperature of melting ice 14.4521 grammes in mass, of a constant cross-sectional area and of the length of 106.3 centimetres.

"As a unit of current, the *international ampère*, which is one tenth of the unit of current of the C. G. S. system of electro-magnetic units, and which is represented sufficiently well for practical use by the unvarying current which, when passed through a solution of nitrate of silver in water, and in accordance with accompanying specifications,* deposits silver at the rate of 0.001118 of a gramme per second.

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* "In the following specification the term 'silver voltameter' means the arrangement of apparatus by means of which an electric current is passed through a solution of nitrate of silver in water. The silver voltameter measures the total electrical quantity which has passed during the time of the experiment, and by noting this time the time average of the current, or, if the current has been kept constant, the current itself can be deduced.

"In employing the silver voltameter to measure currents of about one ampère, the following arrangements should be adopted: —

"As a unit of electromotive force, the *international volt*, which is the electromotive force that, steadily applied to a conductor whose resistance is one international ohm, will produce a current of one international ampère, and which is represented sufficiently well for practical use by $\frac{1000}{1434}$ of the electromotive force between the poles or electrodes of the voltaic cell known as Clark's cell, at a temperature of 15° C., and prepared in the manner described in the accompanying specification.[*]

"As a unit of quantity, the *international coulomb*, which is the quantity of electricity transferred by a current of one international ampère in one second.

"As a unit of capacity, the *international farad*, which is the capacity of a condenser charged to a potential of one international volt by one international coulomb of electricity.[†]

"As a unit of work, the *joule*, which is equal to 10^7 units of work in the c. g. s. system, and which is represented sufficiently well for practical use by the energy expended in one second by an international ampère in an international ohm.

"As a unit of power, the *watt*, which is equal to 10^7 units of power in the c. g. s. system, and which is represented sufficiently well for practical use by the work done at the rate of one joule per second.

"As the unit of induction, the *henry*, which is the induction in a circuit when the electromotive force induced in this circuit is one international volt, while the inducing current varies at the rate of one ampère per second.

"The Chamber also voted that it was not wise to adopt or recommend a standard of light at the present time."

By an Act of Congress approved July 12th, 1894, the units recommended by the Chicago Congress were adopted in this country with only some unimportant verbal changes in the definitions.

By an Order in Council of date August 23d, 1894, the British Board of Trade adopted the ohm, the ampere, and the volt, substantially as recommended by the Chicago Congress. The other units were not legalized in Great Britain. They are, however, in general use in that country and all over the world.

"The kathode on which the silver is to be deposited should take the form of a platinum bowl not less than 10 centimetres in diameter and from 4 to 5 centimetres in depth.

"The anode should be a plate of pure silver some 30 square centimetres in area and 2 or 3 millimetres in thickness.

"This is supported horizontally in the liquid near the top of the solution by a platinum wire passed through holes in the plate at opposite corners. To prevent the disintegrated silver which is formed on the anode from falling on to the kathode, the anode should be wrapped round with pure filter paper, secured at the back with sealing wax.

"The liquid should consist of a neutral solution of pure silver nitrate, containing about 15 parts by weight of the nitrate to 85 parts of water.

"The resistance of the voltameter changes somewhat as the current passes. To prevent these changes having too great an effect on the current, some resistance besides that of the voltameter should be inserted in the circuit. The total metallic resistance of the circuit should not be less than 10 ohms."

[*] A committee, consisting of Messrs. Helmholtz, Ayrton, and Carhart, was appointed to prepare specifications for the Clark's cell, but no report was made, on account of Helmholtz's death.

[†] The one millionth part of the farad is more commonly used in practical measurements, and is called the microfarad.

PHYSICAL TABLES

TABLE 1.

FUNDAMENTAL AND DERIVED UNITS.

To change a quantity from one system of units to another: substitute in the corresponding conversion factor from the following table the ratio of the magnitudes of the *old* units to the *new* and multiply the old quantity by the resulting number. For example: to reduce velocity in miles per hour to feet per second, the conversion factor is $l\,t^{-1}$; l=5280/1, t=3600/1, therefore the factor=5280/3600=1.467.

(*a*) FUNDAMENTAL UNITS.

Name of Unit.	Symbol.	Conversion Factor.
Length.	L	l
Mass.	M	m
Time.	T	t
Temperature.	Θ	θ
Electric Inductive Capacity.	K	k
Magnetic Inductive Capacity.	P	p

(*b*) DERIVED UNITS.

I. Geometric and Dynamic Units.

Name of Unit.	Conversion Factor.
Area.	l^2
Volume.	l^3
Angle.	1
Solid Angle.	1
Curvature.	l^{-1}
Tortuosity.	l^{-1}
Specific curvature of a surface.	l^{-2}
Angular velocity.	t^{-1}
Angular acceleration.	t^{-2}
Linear velocity.	$l\,t^{-1}$
Linear acceleration.	$l\,t^{-2}$
Density.	$m\,l^{-3}$
Moment of inertia.	$m\,l^2$
Intensity of attraction, or "force at a point."	$l\,t^{-2}$
Absolute force of a centre of attraction, or "strength of a centre."	$l^3\,t^{-2}$
Momentum.	$m\,l\,t^{-1}$
Moment of momentum, or angular momentum.	$m\,l^2\,t^{-1}$
Force.	$m\,l\,t^{-2}$
Moment of a couple, or torque.	$m\,l^2\,t^{-2}$
Intensity of stress.	$m\,l^{-1}\,t^{-2}$
Modulus of elasticity.	$m\,l^{-1}\,t^{-2}$
Work and energy.	$m\,l^2\,t^{-2}$
Resilience.	$m\,l^{-1}\,t^{-2}$
Power or activity.	$m\,l^2\,t^{-3}$

FUNDAMENTAL AND DERIVED UNITS.

II. Heat Units.

Name of Unit.	Conversion Factor.
Quantity of heat (thermal units).	$m\ \theta$
" " (thermometric units).	$l^3\ \theta$
" " (dynamical units).	$m\ l^2\ t^{-2}$
Coefficient of thermal expansion.	θ^{-1}
Conductivity (thermal units).	$m\ l^{-1}\ t^{-1}$
" (thermometric units), or diffusivity.	$l^2\ t^{-1}$
" (dynamical units).	$m\ l\ t^{-3}\ \theta^{-1}$
Thermal capacity.	m
Latent heat (thermal units).	θ
" " (dynamical units).	$l^2\ t^{-2}$
Joule's equivalent.	$l^2\ t^{-2}\ \theta$
Entropy (heat measured in thermal units).	m
" (" " " dynamical units).	$m\ l^2\ t^{-2}\ \theta$

III. Magnetic and Electric Units.

Name of Unit.	Conversion factor for electrostatic system.	Conversion factor for electromagnetic system.
Magnetic pole, or quantity of magnetism.	$m^{\frac{1}{2}}\ l^{\frac{1}{2}}\ k^{-\frac{1}{2}}$	$m^{\frac{1}{2}}\ l^{\frac{3}{2}}\ t^{-1}\ p^{\frac{1}{2}}$
Density of surface distribution of magnetism.	$m^{\frac{1}{2}}\ l^{-\frac{3}{2}}\ k^{-\frac{1}{2}}$	$m^{\frac{1}{2}}\ l^{-\frac{1}{2}}\ t^{-1}\ p^{\frac{1}{2}}$
Intensity of magnetic field.	$m^{\frac{1}{2}}\ l^{\frac{1}{2}}\ t^{-2}\ k^{\frac{1}{2}}$	$m^{\frac{1}{2}}\ l^{-\frac{1}{2}}\ t^{-1}\ p^{-\frac{1}{2}}$
Magnetic potential.	$m^{\frac{1}{2}}\ l^{\frac{3}{2}}\ t^{-2}\ k^{\frac{1}{2}}$	$m^{\frac{1}{2}}\ l^{\frac{1}{2}}\ t^{-1}\ p^{-\frac{1}{2}}$
Magnetic moment.	$m^{\frac{1}{2}}\ l^{\frac{3}{2}}\ k^{-\frac{1}{2}}$	$m^{\frac{1}{2}}\ l^{\frac{5}{2}}\ t^{-1}\ p^{\frac{1}{2}}$
Intensity of magnetisation.	$m^{\frac{1}{2}}\ l^{\frac{1}{2}}\ k^{-\frac{1}{2}}$	$m^{\frac{1}{2}}\ l^{-\frac{1}{2}}\ t^{-1}\ p^{\frac{1}{2}}$
Magnetic permeability.	I	I
Magnetic susceptibility and magnetic inductive capacity.	$l^{-2}\ t^2\ k^{-1}$	p
Quantity of electricity.	$m^{\frac{1}{2}}\ l^{\frac{3}{2}}\ t^{-1}\ k^{\frac{1}{2}}$	$m^{\frac{1}{2}}\ l^{\frac{1}{2}}\ p^{-\frac{1}{2}}$
Electric surface density and electric displacement.	$m^{\frac{1}{2}}\ l^{-\frac{1}{2}}\ t^{-1}\ k^{\frac{1}{2}}$	$m^{\frac{1}{2}}\ l^{-\frac{3}{2}}\ p^{-\frac{1}{2}}$
Intensity of electric field.	$m^{\frac{1}{2}}\ l^{-\frac{1}{2}}\ t^{-1}\ k^{-\frac{1}{2}}$	$m^{\frac{1}{2}}\ l^{\frac{1}{2}}\ t^{-2}\ p^{\frac{1}{2}}$
Electric potential and e. m. f.	$m^{\frac{1}{2}}\ l^{\frac{1}{2}}\ t^{-1}\ k^{-\frac{1}{2}}$	$m^{\frac{1}{2}}\ l^{\frac{3}{2}}\ t^{-2}\ p^{\frac{1}{2}}$
Capacity of a condenser.	$l\ k$	$l^{-1}\ t^2\ p^{-1}$
Inductive capacity.	k	$l^{-2}\ t^2\ p^{-1}$
Specific inductive capacity.	I	I
Electric current.	$m^{\frac{1}{2}}\ l^{\frac{3}{2}}\ t^{-2}\ k^{\frac{1}{2}}$	$m^{\frac{1}{2}}\ l^{\frac{1}{2}}\ t^{-1}\ p^{-\frac{1}{2}}$

TABLE 1.

FUNDAMENTAL AND DERIVED UNITS.

III. Magnetic and Electric Units.

Name of Unit.	Conversion factor for electrostatic system.	Conversion factor for electromagnetic system.
Conductivity.	$t^{-1} k$	$l^{-2} t p^{-1}$
Specific resistance.	$t k^{-1}$	$l^2 t^{-1} p$
Conductance.	$l t^{-1} k$	$l^{-1} t p^{-1}$
Resistance.	$l^{-1} t k^{-1}$	$l t^{-1} p$
Coefficient of self induction and coefficient of mutual induction.	$l^{-1} t^2 k^{-1}$	$l p$
Electrokinetic momentum.	$m^{\frac{1}{2}} l^{\frac{1}{2}} k^{-\frac{1}{2}}$	$m^{\frac{1}{2}} l^{\frac{3}{2}} t^{-1} p^{\frac{1}{2}}$
Electromotive force at a point.	$m^{\frac{1}{2}} l^{-\frac{1}{2}} t^{-1} k^{-\frac{1}{2}}$	$m^{\frac{1}{2}} l^{\frac{1}{2}} t^{-2} p^{\frac{1}{2}}$
Vector potential.	$m^{\frac{1}{2}} l^{-\frac{1}{2}} k^{-\frac{1}{2}}$	$m^{\frac{1}{2}} l^{\frac{1}{2}} t^{-1} p^{\frac{1}{2}}$
Thermoelectric height and specific heat of electricity.	$m^{\frac{1}{2}} l^{\frac{1}{2}} t^{-1} k^{-\frac{1}{2}} \theta^{-1}$	$m^{\frac{1}{2}} l^{\frac{3}{2}} t^{-2} p^{\frac{1}{2}} \theta^{-1}$
Coefficient of Peltier effect.	$m^{\frac{1}{2}} l^{-\frac{3}{2}} t k^{-\frac{1}{2}} \theta$	$m^{\frac{1}{2}} l^{-\frac{1}{2}} p^{\frac{1}{2}} \theta$

Table 2.

TABLES FOR CONVERTING U. S. WEIGHTS AND MEASURES.*

(1) CUSTOMARY TO METRIC.

LINEAR.

	Inches to millimetres.	Feet to metres.	Yards to metres.	Miles to kilometres.
1	25.4001	0.304801	0.914402	1.60935
2	50.8001	0.609601	1.828804	3.21869
3	76.2002	0.914402	2.743205	4.82804
4	101.6002	1.219202	3.657607	6.43739
5	127.0003	1.524003	4.572009	8.04674
6	152.4003	1.828804	5.486411	9.65608
7	177.8004	2.133604	6.400813	11.26543
8	203.2004	2.438405	7.315215	12.87478
9	228.6005	2.743205	8.229616	14.48412

CAPACITY.

	Fluid drams to millilitres or cubic centimetres.	Fluid ounces to millilitres.	Liquid quarts to litres.	Gallons to litres.
1	3.70	29.57	0.94636	3.78543
2	7.39	59.15	1.89272	7.57087
3	11.09	88.72	2.83908	11.35630
4	14.79	118.29	3.78543	15.14174
5	18.48	147.87	4.73179	18.92717
6	22.18	177.44	5.67815	22.71261
7	25.88	207.02	6.62451	26.49804
8	29.57	236.59	7.57087	30.28348
9	33.27	266.16	8.51723	34.06891

SQUARE.

	Square inches to square centimetres.	Square feet to square decimetres.	Square yards to square metres.	Acres to hectares.
1	6.452	9.290	0.836	0.4047
2	12.903	18.581	1.672	0.8094
3	19.355	27.871	2.508	1.2141
4	25.807	37.161	3.345	1.6187
5	32.258	46.452	4.181	2.0234
6	38.710	55.742	5.017	2.4281
7	45.161	65.032	5.853	2.8328
8	51.613	74.323	6.689	3.2375
9	58.065	83.613	7.525	3.6422

WEIGHT.

	Grains to milligrammes.	Avoirdupois ounces to grammes.	Avoirdupois pounds to kilogrammes.	Troy ounces to grammes.
1	64.7989	28.3495	0.45359	31.10348
2	129.5978	56.6991	0.90718	62.20696
3	194.3968	85.0486	1.36078	93.31044
4	259.1957	113.3981	1.81437	124.41392
5	323.9946	141.7476	2.26796	155.51740
6	388.7935	170.0972	2.72155	186.62088
7	453.5924	198.4467	3.17515	217.72437
8	518.3913	226.7962	3.62874	248.82785
9	583.1903	255.1457	4.08233	279.93133

CUBIC.

	Cubic inches to cubic centimetres.	Cubic feet to cubic metres.	Cubic yards to cubic metres.	Bushels to hectolitres.
1	16.387	0.02832	0.765	0.35239
2	32.774	0.05663	1.529	0.70479
3	49.161	0.08495	2.294	1.05718
4	65.549	0.11327	3.058	1.40957
5	81.936	0.14159	3.823	1.76196
6	98.323	0.16990	4.587	2.11436
7	114.710	0.19822	5.352	2.46675
8	131.097	0.22654	6.116	2.81914
9	147.484	0.25485	6.881	3.17154

1 Gunter's chain	=	20.1168	metres.
1 sq. statute mile	=	259.000	hectares.
1 fathom	=	1.829	metres.
1 nautical mile	=	1853.25	metres.
1 foot	=	0.304801	metre.
1 avoir. pound	=	453.5924277	grammes.
15432.35639 grains	=	1.000	kilogramme.

According to an executive order dated April 15, 1893, the United States yard is defined as 3600/3937 metre, and the avoirdupois pound as 1/2.20462 kilogramme.

The only authorized material standard of customary weight is the Troy pound of the Mint. It is of brass of unknown density, and therefore not suitable for a standard of mass. It was derived from the British standard Troy pound of 1758 by direct comparison.

The British gallon = 4.5459631 litres.

The British bushel = 36.3477 litres.

The length of the nautical mile given above and adopted by the U. S. Coast and Geodetic Survey many years ago, is defined as that of a minute of arc of a great circle of a sphere whose surface equals that of the earth (Clarke's Spheroid of 1866).

* Quoted from sheets issued by the United States Bureau of Standards.

TABLE 2.

TABLES FOR CONVERTING U. S. WEIGHTS AND MEASURES.

(2) METRIC TO CUSTOMARY.

LINEAR.

	Metres to inches.	Metres to feet.	Metres to yards.	Kilometres to miles.
1	39.3700	3.28083	1.093611	0.62137
2	78.7400	6.56167	2.187222	1.24274
3	118.1100	9.84250	3.280833	1.86411
4	157.4800	13.12333	4.374444	2.48548
5	196.8500	16.40417	5.468056	3.10685
6	236.2200	19.68500	6.561667	3.72822
7	275.5900	22.96583	7.655278	4.34959
8	314.9600	26.24667	8.748889	4.97096
9	354.3300	29.52750	9.842500	5.59233

CAPACITY.

	Millilitres or cubic centimetres to fluid drams.	Centilitres to fluid ounces.	Litres to quarts.	Decalitres to gallons.	Hectolitres to bushels.
1	0.27	0.338	1.0567	2.6417	2.8377
2	0.54	0.676	2.1134	5.2834	5.6755
3	0.81	1.014	3.1700	7.9251	8.5132
4	1.08	1.353	4.2267	10.5668	11.3510
5	1.35	1.691	5.2834	13.2085	14.1887
6	1.62	2.029	6.3401	15.8502	17.0265
7	1.89	2.367	7.3968	18.4919	19.8642
8	2.16	2.705	8.4535	21.1336	22.7019
9	2.43	3.043	9.5101	23.7753	25.5397

SQUARE.

	Square centimetres to square inches.	Square metres to square feet.	Square metres to square yards.	Hectares to acres.
1	0.1550	10.764	1.196	2.471
2	0.3100	21.528	2.392	4.942
3	0.4650	32.292	3.588	7.413
4	0.6200	43.055	4.784	9.884
5	0.7750	53.819	5.980	12.355
6	0.9300	64.583	7.176	14.826
7	1.0850	75.347	8.372	17.297
8	1.2400	86.111	9.568	19.768
9	1.3950	96.875	10.764	22.239

WEIGHT.

	Milligrammes to grains.	Kilogrammes to grains.	Hectogrammes to ounces avoirdupois.	Kilogrammes to pounds avoirdupois.
1	0.01543	15432.36	3.5274	2.20462
2	0.03086	30864.71	7.0548	4.40924
3	0.04630	46297.07	10.5822	6.61387
4	0.06173	61729.43	14.1096	8.81849
5	0.07716	77161.78	17.6370	11.02311
6	0.09259	92594.14	21.1644	13.22773
7	0.10803	108026.49	24.6918	15.43236
8	0.12346	123458.85	28.2192	17.63698
9	0.13889	138891.21	31.7466	19.84160

CUBIC.

	Cubic centimetres to cubic inches.	Cubic decimetres to cubic inches.	Cubic metres to cubic feet.	Cubic metres to cubic yards.
1	0.0610	61.023	35.314	1.308
2	0.1220	122.047	70.629	2.616
3	0.1831	183.070	105.943	3.924
4	0.2441	244.094	141.258	5.232
5	0.3051	305.117	176.572	6.540
6	0.3661	366.140	211.887	7.848
7	0.4272	427.164	247.201	9.156
8	0.4882	488.187	282.516	10.464
9	0.5492	549.210	317.830	11.771

WEIGHT.

	Quintals to pounds av.	Milliers or tonnes to pounds av.	Kilogrammes to ounces Troy.
1	220.46	2204.6	32.1507
2	440.92	4409.2	64.3015
3	661.39	6613.9	96.4522
4	881.85	8818.5	128.6030
5	1102.31	11023.1	160.7537
6	1322.77	13227.7	192.9045
7	1543.24	15432.4	225.0552
8	1763.70	17637.0	257.2059
9	1984.16	19841.6	289.3567

By the concurrent action of the principal governments of the world an International Bureau of Weights and Measures has been established near Paris. Under the direction of the International Committee, two ingots were cast of pure platinum-iridium in the proportion of 9 parts of the former to 1 of the latter metal. From one of these a certain number of kilogrammes were prepared, from the other a definite number of metre bars. These standards of weight and length were intercompared, without preference, and certain ones were selected as International prototype standards. The others were distributed by lot, in September, 1889, to the different governments, and are called National prototype standards. Those apportioned to the United States were received in 1890, and are kept at the Bureau of Standards in Washington, D. C.

The metric system was legalized in the United States in 1866.

The International Standard Metre is derived from the Mètre des Archives, and its length is defined by the distance between two lines at 0° Centigrade, on a platinum-iridium bar deposited at the International Bureau of Weights and Measures.

The International Standard Kilogramme is a mass of platinum-iridium deposited at the same place, and its weight in vacuo is the same as that of the Kilogramme des Archives.

The litre is equal to a cubic decimetre, and it is measured by the quantity of distilled water which, at its maximum density, will counterpoise the standard kilogramme in a vacuum, the volume of such a quantity of water being, as nearly as has been ascertained, equal to a cubic decimetre.

TABLE 3.

EQUIVALENTS OF METRIC AND BRITISH IMPERIAL WEIGHTS AND MEASURES.*

(1) METRIC TO IMPERIAL.

LINEAR MEASURE.

1 millimetre (mm.) (.001 m.)	=	0.03937 in.
1 centimetre (.01 m.)	=	0.39370 "
1 decimetre (.1 m.)	=	3.93701 "
1 METRE (m.) . . .	=	39.370113 " 3.280843 ft. 1.09361425 yds.
1 dekametre (10 m.) . . .	=	10.93614 "
1 hectometre (100 m.) . . .	=	109.361425 "
1 kilometre (1,000 m.) . . .	=	0.62137 mile.
1 myriametre (10,000 m.) . .	=	6.21372 miles.
1 micron	=	0.001 mm.

SQUARE MEASURE.

1 sq. centimetre . .	=	0.1550 sq. in.
1 sq. decimetre (100 sq. centm.)	=	15.500 sq. in.
1 sq. metre or centiare (100 sq. dcm.)	=	10.7639 sq. ft. 1.1960 sq. yds.
1 ARE (100 sq. m.)	=	119.60 sq. yds.
1 hectare (100 ares or 10,000 sq. m.)	=	2.4711 acres.

CUBIC MEASURE.

1 cub. centimetre (c.c.) (1,000 cubic millimetres)	=	0.0610 cub. in.
1 cub. decimetre (c.d.) (1,000 cubic centimetres)	=	61.024 " "
1 CUB. METRE or stere (1,000 c.d.) . .	=	35.3148 cub. ft. 1.307954 cub. yds.

MEASURE OF CAPACITY.

1 millilitre (ml.) (.001 litre)	=	0.0610 cub. in.
1 centilitre (.01 litre)	=	0.61024 " " 0.070 gill.
1 decilitre (.1 litre) . .	=	0.176 pint.
1 LITRE (1,000 cub. centimetres or 1 cub. decimetre)	=	1.75980 pints.
1 dekalitre (10 litres) .	=	2.200 gallons.
1 hectolitre (100 ") .	=	2.75 bushels.
1 kilolitre (1,000 ") .	=	3.437 quarters.

APOTHECARIES' MEASURE.

1 cubic centimetre (1 gramme w't)	=	0.03520 fluid ounce. 0.28157 fluid drachm. 15.43236 grains weight.
1 cub. millimetre	=	0.01693 minim.

AVOIRDUPOIS WEIGHT.

1 milligramme (mgr.) . .	=	0.01543 grain.
1 centigramme (.01 gram.)	=	0.15432 "
1 decigramme (.1 ")	=	1.54324 grains.
1 GRAMME	=	15.43236 "
1 dekagramme (10 gram.)	=	5.64383 drams.
1 hectogramme (100 ")	=	3.52739 oz.
1 KILOGRAMME (1,000 ")	=	2.2046223 lbs. 15432.3564 grains.
1 myriagramme (10 kilog.)	=	22.04622 lbs.
1 quintal (100 ")	=	1.96841 cwt.
1 millier or tonne (1,000 kilog.) . .	=	0.9842 ton.

TROY WEIGHT.

1 GRAMME . .	=	0.03215 oz. Troy. 0.64301 pennyweight. 15.43236 grains.

APOTHECARIES' WEIGHT.

1 GRAMME	=	0.25721 drachm. 0.77162 scruple. 15.43236 grains.

NOTE.—The METRE is the length, at the temperature of 0° C., of the platinum-iridium bar deposited at the International Bureau of Weights and Measures at Sevres, near Paris, France.

The present legal equivalent of the metre is 39.370113 inches, as above stated.

The KILOGRAMME is the mass of a platinum-iridium weight deposited at the same place.

The LITRE contains one kilogramme weight of distilled water at its maximum density (4° C.), the barometer being at 760 millimetres.

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*In accordance with the schedule adopted under the Weights and Measures (metric system) Act, 1897.

Table 3.

EQUIVALENTS OF METRIC AND BRITISH IMPERIAL WEIGHTS AND MEASURES.

(2) METRIC TO IMPERIAL.

LINEAR MEASURE.				
	Millimetres to inches.	Metres to feet.	Metres to yards.	Kilo-metres to miles.
1	0.03937011	3.28084	1.09361	0.62137
2	0.07874023	6.56169	2.18723	1.24274
3	0.11811034	9.84253	3.28084	1.86412
4	0.15748045	13.12337	4.37446	2.48549
5	0.19685056	16.40421	5.46807	3.10686
6	0.23622068	19.68506	6.56169	3.72823
7	0.27559079	22.96590	7.65530	4.34960
8	0.31496090	26.24674	8.74891	4.97097
9	0.35433102	29.52758	9.84253	5.59235

MEASURE OF CAPACITY.				
	Litres to pints.	Dekalitres to gallons.	Hectolitres to bushels.	Kilolitres to quarters.
1	1.75980	2.19975	2.74969	3.43712
2	3.51961	4.39951	5.49938	6.87423
3	5.27941	6.59926	8.24908	10.31135
4	7.03921	8.79902	10.99877	13.74846
5	8.79902	10.99877	13.74846	17.18558
6	10.55882	13.19852	16.49815	20.62269
7	12.31862	15.39828	19.24785	24.05981
8	14.07842	17.59803	21.99754	27.49692
9	15.83823	19.79778	24.74723	30.93404

SQUARE MEASURE.				
	Square centimetres to square inches.	Square metres to square feet.	Square metres to square yards.	Hectares to acres.
1	0.15500	10.76393	1.19599	2.4711
2	0.31000	21.52786	2.39198	4.9421
3	0.46500	32.29179	3.58798	7.4132
4	0.62000	43.05572	4.78397	9.8842
5	0.77500	53.81965	5.97996	12.3553
6	0.93000	64.58357	7.17595	14.8263
7	1.08500	75.34750	8.37194	17.2974
8	1.24000	86.11143	9.56794	19.7685
9	1.39501	96.87536	10.76393	22.2395

WEIGHT (Avoirdupois).				
	Milli-grammes to grains.	Kilogrammes to grains.	Kilo-grammes to pounds.	Quintals to hundred-weights.
1	0.01543	15432.356	2.20462	1.96841
2	0.03086	30864.713	4.40924	3.93683
3	0.04630	46297.069	6.61387	5.90524
4	0.06173	61729.426	8.81849	7.87365
5	0.07716	77161.782	11.02311	9.84206
6	0.09259	92594.138	13.22773	11.81048
7	0.10803	108026.495	15.43236	13.77889
8	0.12346	123458.851	17.63698	15.74730
9	0.13889	138891.208	19.84160	17.71572

CUBIC MEASURE.				Apothecaries' Measure.
	Cubic decimetres to cubic inches.	Cubic metres to cubic feet.	Cubic metres to cubic yards.	Cub. centimetres to fluid drachms.
1	61.02390	35.31476	1.30795	0.28157
2	122.04781	70.62952	2.61591	0.56314
3	183.07171	105.94428	3.92386	0.84471
4	244.09561	141.25904	5.23182	1.12627
5	305.11952	176.57379	6.53977	1.40784
6	366.14342	211.88855	7.84772	1.68941
7	427.16732	247.20331	9.15568	1.97098
8	488.19123	282.51807	10.46363	2.25255
9	549.21513	317.83283	11.77159	2.53412

	Avoirdupois (*cont.*)	Troy Weight.		Apothecaries' Weight.
	Milliers or tonnes to tons.	Grammes to ounces Troy.	Grammes to penny-weights.	Grammes to scruples.
1	0.98421	0.03215	0.64301	0.77162
2	1.96841	0.06430	1.28603	1.54324
3	2.95262	0.09645	1.92904	2.31485
4	3.93683	0.12860	2.57206	3.08647
5	4.92103	0.16075	3.21507	3.85809
6	5.90524	0.19290	3.85809	4.62971
7	6.88944	0.22506	4.50110	5.40132
8	7.87365	0.25721	5.14412	6.17294
9	8.85786	0.28936	5.78713	6.94456

TABLE 3.

EQUIVALENTS OF BRITISH IMPERIAL AND METRIC WEIGHTS AND MEASURES.

(3) IMPERIAL TO METRIC.

LINEAR MEASURE.

1 inch . . . . . . = 25.400 millimetres.
1 foot (12 in.) . . = 0.30480 metre.
1 YARD (3 ft.) . . = 0.914399 "
1 pole (5½ yd.) . . = 5.0292 metres.
1 chain (22 yd. or 100 links) = 20.1168 "
1 furlong (220 yd.) = 201.168 "
1 mile (1,760 yd.) . = 1.6093 kilometres.

SQUARE MEASURE.

1 square inch . . = 6.4516 sq. centimetres.
1 sq. ft. (144 sq. in.) = 9.2903 sq. decimetres.
1 SQ. YARD (9 sq. ft.) = 0.836126 sq. metres.
1 perch (30¼ sq. yd.) = 25.293 sq. metres.
1 rood (40 perches) = 10.117 ares.
1 ACRE (4840 sq. yd.) = 0.40468 hectare.
1 sq. mile (640 acres) = 259.00 hectares.

CUBIC MEASURE.

1 cub. inch = 16.387 cub. centimetres.
1 cub. foot (1728 cub. in.) = 0.028317 cub. metre, or 28.317 cub. decimetres.
1 CUB. YARD (27 cub. ft.) = 0.76455 cub. metre.

APOTHECARIES' MEASURE.

1 gallon (8 pints or 160 fluid ounces) = 4.5459631 litres.
1 fluid ounce, f ℥ (8 drachms) = 28.4123 cubic centimetres.
1 fluid drachm, f ʒ (60 minims) = 3.5515 cubic centimetres.
1 minim, ♏ (0.91146 grain weight) = 0.05919 cubic centimetres.

NOTE. — The Apothecaries' gallon is of the same capacity as the Imperial gallon.

MEASURE OF CAPACITY.

1 gill . . . . = 1.42 decilitres.
1 pint (4 gills) . . . = 0.568 litre.
1 quart (2 pints) . . = 1.136 litres.
1 GALLON (4 quarts) = 4.5459631 "
1 peck (2 galls.) . . = 9.092 "
1 bushel (8 galls.) . = 3.637 dekalitres.
1 quarter (8 bushels) = 2.909 hectolitres.

AVOIRDUPOIS WEIGHT.

1 grain . . . . . . = 64.8 milligrammes.
1 dram . . . . . . = 1.772 grammes.
1 ounce (16 dr.) . . = 28.350 "
1 POUND (16 oz. or 7,000 grains) = 0.45359243 kilogr.
1 stone (14 lb.) . . = 6.350 "
1 quarter (28 lb.) . = 12.70 "
1 hundredweight (112 lb.) = 50.80 " 0.5080 quintal.
1 ton (20 cwt.) . = 1.0160 tonnes or 1016 kilogrammes.

TROY WEIGHT.

1 Troy OUNCE (480 grains avoir.) = 31.1035 grammes.
1 pennyweight (24 grains) = 1.5552 "

NOTE. — The Troy grain is of the same weight as the Avoirdupois grain.

APOTHECARIES' WEIGHT.

1 ounce (8 drachms) = 31.1035 grammes.
1 drachm, ʒi (3 scruples) = 3.888 "
1 scruple, ℈i (20 grains) = 1.296 "

NOTE. — The Apothecaries' ounce is of the same weight as the Troy ounce. The Apothecaries' grain is also of the same weight as the Avoirdupois grain.

NOTE. — The YARD is the length at 62° Fahr., marked on a bronze bar deposited with the Board of Trade.

The POUND is the weight of a piece of platinum weighed in vacuo at the temperature of 0° C., and which is also deposited with the Board of Trade.

The GALLON contains 10 lb. weight of distilled water at the temperature of 62° Fahr., the barometer being at 30 inches.

TABLE 3.

EQUIVALENTS OF BRITISH IMPERIAL AND METRIC WEIGHTS AND MEASURES.

(4) IMPERIAL TO METRIC.

LINEAR MEASURE.

	Inches to centimetres.	Feet to metres.	Yards to metres.	Miles to kilometres.
1	2.539998	0.30480	0.91440	1.60934
2	5.079996	0.60960	1.82880	3.21869
3	7.619993	0.91440	2.74320	4.82803
4	10.159991	1.21920	3.65760	6.43737
5	12.699989	1.52400	4.57200	8.04671
6	15.239987	1.82880	5.48640	9.65606
7	17.779984	2.13360	6.40080	11.26540
8	20.319982	2.43840	7.31519	12.87474
9	22.859980	2.74320	8.22959	14.48408

MEASURE OF CAPACITY.

	Quarts to litres.	Gallons to litres.	Bushels to dekalitres.	Quarters to hectolitres.
1	1.13649	4.54596	3.63677	2.90942
2	2.27298	9.09193	7.27354	5.81883
3	3.40947	13.63789	10.91031	8.72825
4	4.54596	18.18385	14.54708	11.63767
5	5.68245	22.72982	18.18385	14.54708
6	6.81894	27.27578	21.82062	17.45650
7	7.95544	31.82174	25.45739	20.36591
8	9.09193	36.36770	29.09416	23.27533
9	10.22842	40.91367	32.73093	26.18475

SQUARE MEASURE.

	Square inches to square centimetres.	Square feet to square decimetres.	Square yards to square metres.	Acres to hectares.
1	6.45159	9.29029	0.83613	0.40468
2	12.90318	18.58058	1.67225	0.80937
3	19.35477	27.87086	2.50838	1.21405
4	25.80636	37.16115	3.34450	1.61874
5	32.25794	46.45144	4.18063	2.02342
6	38.70953	55.74173	5.01676	2.42811
7	45.16112	65.03201	5.85288	2.83279
8	51.61271	74.32230	6.68901	3.23748
9	58.06430	83.61259	7.52513	3.64216

WEIGHT (AVOIRDUPOIS).

	Grains to milligrammes.	Ounces to grammes.	Pounds to kilogrammes.	Hundredweights to quintals.
1	64.79892	28.34953	0.45359	0.50802
2	129.59784	56.69905	0.90718	1.01605
3	194.39675	85.04858	1.36078	1.52407
4	259.19567	113.39811	1.81437	2.03209
5	323.99459	141.74763	2.26796	2.54012
6	388.79351	170.09716	2.72155	3.04814
7	453.59243	198.44669	3.17515	3.55616
8	518.39135	226.79621	3.62874	4.06419
9	583.19026	255.14574	4.08233	4.57221

	CUBIC MEASURE.			APOTHECARIES' MEASURE.
	Cubic inches to cubic centimetres.	Cubic feet to cubic metres.	Cubic yards to cubic metres	Fluid drachms to cubic centimetres.
1	16.38702	0.02832	0.76455	3.55153
2	32.77404	0.05663	1.52911	7.10307
3	49.16106	0.08495	2.29366	10.65460
4	65.54808	0.11327	3.05821	14.20613
5	81.93511	0.14158	3.82276	17.75767
6	98.32213	0.16990	4.58732	21.30920
7	114.70915	0.19822	5.35187	24.86074
8	131.09617	0.22653	6.11642	28.41227
9	147.48319	0.25485	6.88098	31.96380

	AVOIRDUPOIS (*cont.*).	TROY WEIGHT.		APOTHECARIES' WEIGHT.
	Tons to milliers or tonnes.	Ounces to grammes.	Pennyweights to grammes.	Scruples to grammes.
1	1.01605	31.10348	1.55517	1.29598
2	2.03209	62.20696	3.11035	2.59196
3	3.04814	93.31044	4.66552	3.88794
4	4.06419	124.41392	6.22070	5.18391
5	5.08024	155.51740	7.77587	6.47989
6	6.09628	186.62088	9.33104	7.77587
7	7.11233	217.72437	10.88622	9.07185
8	8.12838	248.82785	12.44139	10.36783
9	9.14442	279.93133	13.99657	11.66381

TABLE 4.

VOLUME OF A GLASS VESSEL FROM THE WEIGHT OF ITS EQUIVALENT VOLUME OF MERCURY OR WATER.

If a glass vessel contains at t° C, P grammes of mercury, weighted with brass weights in air at 760 mm. pressure, then its volume in c. cm.

at the same temperature, t, : $V = PR = P\frac{p}{d}$,

at another temperature, t_1, : $V = PR_1 = Pp/d\,\{1 + \gamma\,(t_1 - t)\}$

p = the weight, reduced to vacuum, of the mass of mercury or water which, weighed with brass weights, equals 1 gramme;

d = the density of mercury or water at t° C,

and $\gamma = 0.000\,025$, is the cubical expansion coefficient of glass.

Temperature t	WATER.			MERCURY.		
	R.	R_1, $t_1 = 10^\circ$.	R_1, $t_1 = 20^\circ$.	R.	R_1, $t_1 = 10^\circ$.	R_1, $t_1 = 20^\circ$.
0°	1.001192	1.001443	1.001693	0.0735499	0.0735683	0.0735867
1	1133	1358	1609	5633	5798	5982
2	1092	1292	1542	5766	5914	6098
3	1068	1243	1493	5900	6029	6213
4	1060	1210	1460	6033	6144	6328
5	1068	1193	1443	6167	6259	6443
6	1.001092	1.001192	1.001442	0.0736301	0.0736374	0.0736558
7	1131	1206	1456	6434	6490	6674
8	1184	1234	1485	6568	6605	6789
9	1252	1277	1527	6702	6720	6904
10	1333	1333	1584	6835	6835	7020
11	1.001428	1.001403	001653	0.0736969	0.0736951	0.0737135
12	1536	1486	1736	7103	7066	7250
13	1657	1582	1832	7236	7181	7365
14	1790	1690	1940	7370	7297	7481
15	1935	1810	2060	7504	7412	7596
16	1.002092	1.001942	1.002193	0.0737637	0.0737527	0.0737711
17	2261	2086	2337	7771	7642	7826
18	2441	2241	2491	7905	7757	7941
19	2633	2407	2658	8039	7872	8057
20	2835	2584	2835	8172	7988	8172
21	1.003048	1.002772	1.003023	0.0738306	0.0738103	0.0738288
22	3271	2970	3220	8440	8218	8403
23	3504	3178	3429	8573	8333	8518
24	3748	3396	3647	8707	8449	8633
25	4001	3624	3875	8841	8564	8748
26	1.004264	1.003862	1.004113	0.0738974	0.0738679	0.0738864
27	4537	4110	4361	9108	8794	8979
28	4818	4366	4616	9242	8910	9094
29	5110	4632	4884	9376	9025	9210
30	5410	4908	5159	9510	9140	9325

Taken from Landolt, Börnstein, and Meyerhoffer's Physikalisch-Chemische Tabellen.

TABLE 5.

DIFFERENTIAL COEFFICIENTS.

INTEGRALS.

DIFFERENTIAL COEFFICIENTS.	
$u=x^n$	$\frac{du}{dx}=nx^{n-1}$
a^x	$a^x \log_e a$
e^x	e^x
$\log_e x$	$\frac{1}{x}$
$\sin. x$	$\cos. x$
$\cos. x$	$-\sin. x$
$\tan. x$	$\sec.^2 x$
$\cot. x$	$-\text{cosec.}^2 x$
$\sec. x$	$\frac{\sin. x}{\cos.^2 x}$
$\text{cosec.}\ x$	$-\frac{\cos. x}{\sin.^2 x}$
$\sin.^{-1} x$	$\frac{1}{\sqrt{(1-x^2)}}$
$\cos.^{-1} x$	$-\frac{1}{\sqrt{(1-x^2)}}$
$\tan.^{-1} x$	$\frac{1}{1+x^2}$
$\cot.^{-1} x$	$-\frac{1}{1+x^2}$
$\sec.^{-1} x$	$\frac{1}{x\sqrt{(x^2-1)}}$
$\text{cosec.}^{-1} x$	$-\frac{1}{x\sqrt{(x^2-1)}}$
$\text{vers.}^{-1} x$	$\frac{1}{\sqrt{(2x-x^2)}}$
$\text{covers.}^{-1} x$	$\frac{1}{\sqrt{(2x-x^2)}}$

INTEGRALS.	
$\int x^n dx$	$=\frac{x^{n+1}}{n+1}$
$\int a^x dx$	$\frac{a^x}{\log_e a}$
$\int e^x dx$	e^x
$\int \frac{dx}{x}$	$\log_e x$
$\int \cos. ax \cdot dx$	$\frac{\sin. ax}{a}$
$\int \sin. ax \cdot dx$	$\frac{-\cos. ax}{a}$
$\int \sec.^2 ax \cdot dx$	$\frac{\tan. ax}{a}$
$\int \text{cosec.}^2 ax \cdot dx$	$\frac{-\cot. ax}{a}$
$\int \frac{\sin. x}{\cos.^2 x} dx$	$\sec. x$
$\int \frac{\cos. x}{\sin.^2 x} dx$	$-\text{cosec.}\ x$
$\int \frac{dx}{\sqrt{(a^2-x^2)}}$	$\begin{cases} \sin.^{-1} \frac{x}{a} \\ -\cos.^{-1} \frac{x}{a} \end{cases}$
$\int \frac{dx}{a^2+x^2}$	$\begin{cases} \frac{1}{a} \tan.^{-1} \frac{x}{a} \\ -\frac{1}{a} \cot.^{-1} \frac{x}{a} \end{cases}$
$\int \frac{dx}{x\sqrt{(x^2-a^2)}}$	$\begin{cases} \frac{1}{a} \sec.^{-1} \frac{x}{a} \\ -\frac{1}{a} \text{cosec.}^{-1} \frac{x}{a} \end{cases}$
$\int \frac{dx}{\sqrt{(2x-x^2)}}$	$\begin{cases} \text{vers.}^{-1} x \\ -\text{covers.}^{-1} x \end{cases}$

Taylor's series:

$$u=f(x+h)=f(x)+f'(x)h+f''(x)\frac{h^2}{2}+f'''(x)\frac{h^3}{1\cdot 2\cdot 3}+\cdots\cdots$$

The remainder after the first *n* terms is expressed by

$$\frac{1}{1\cdot 2\cdot 3\cdots n}\int_o^n f^{n+1}(x+h-z)z^n\cdot dz.$$

Maclaurin's series:

$$u=f(x)=f(o)+f'(o)x+f''(o)\frac{x^2}{1\cdot 2}+f'''(o)\frac{x^3}{1\cdot 2\cdot 3}+\cdots$$

$\pi=3.14159265359$
$\frac{1}{\pi}=0.31830988618$
$\pi^2=9.86960440109$
$e=2.71828182846$
$\sqrt{\pi}=1.77245385091$
$\frac{\sqrt{\pi}}{2}=0.88622692546$

$\log_{10} \pi=0.497149872694$
$\log_{10} e=0.434294481903$
$\log_e 10=2.302585092994$
$\log_B(\text{number})=\log_e(\text{number})\cdot\log_B e$
$=\frac{\log_e(\text{number})}{\log_e B}$

TABLE 6.

VALUES OF RECIPROCALS, SQUARES, CUBES, SQUARE ROOTS, OF NATURAL NUMBERS.

n	$1000.\frac{1}{n}$	n^2	n^3	$\sqrt{n}$	n	$1000.\frac{1}{n}$	n^2	n^3	$\sqrt{n}$
10	100.000	100	1000	3.1623	**65**	15.3846	4225	274625	8.0623
11	90.9091	121	1331	3.3166	66	15.1515	4356	287496	8.1240
12	83.3333	144	1728	3.4641	67	14.9254	4489	300763	8.1854
13	76.9231	169	2197	3.6056	68	14.7059	4624	314432	8.2462
14	71.4286	196	2744	3.7417	69	14.4928	4761	328509	8.3066
15	66.6667	225	3375	3.8730	**70**	14.2857	4900	343000	8.3666
16	62.5000	256	4096	4.0000	71	14.0845	5041	357911	8.4261
17	58.8235	289	4913	4.1231	72	13.8889	5184	373248	8.4853
18	55.5556	324	5832	4.2426	73	13.6986	5329	389017	8.5440
19	52.6316	361	6859	4.3589	74	13.5135	5476	405224	8.6023
20	50.0000	400	8000	4.4721	**75**	13.3333	5625	421875	8.6603
21	47.6190	441	9261	4.5826	76	13.1579	5776	438976	8.7178
22	45.4545	484	10648	4.6904	77	12.9870	5929	456533	8.7750
23	43.4783	529	12167	4.7958	78	12.8205	6084	474552	8.8318
24	41.6667	576	13824	4.8990	79	12.6582	6241	493039	8.8882
25	40.0000	625	15625	5.0000	**80**	12.5000	6400	512000	8.9443
26	38.4615	676	17576	5.0990	81	12.3457	6561	531441	9.0000
27	37.0370	729	19683	5.1962	82	12.1951	6724	551368	9.0554
28	35.7143	784	21952	5.2915	83	12.0482	6889	571787	9.1104
29	34.4828	841	24389	5.3852	84	11.9048	7056	592704	9.1652
30	33.3333	900	27000	5.4772	**85**	11.7647	7225	614125	9.2195
31	32.2581	961	29791	5.5678	86	11.6279	7396	636056	9.2736
32	31.2500	1024	32768	5.6569	87	11.4943	7569	658503	9.3274
33	30.3030	1089	35937	5.7446	88	11.3636	7744	681472	9.3808
34	29.4118	1156	39304	5.8310	89	11.2360	7921	704969	9.4340
35	28.5714	1225	42875	5.9161	**90**	11.1111	8100	729000	9.4868
36	27.7778	1296	46656	6.0000	91	10.9890	8281	753571	9.5394
37	27.0270	1369	50653	6.0828	92	10.8696	8464	778688	9.5917
38	26.3158	1444	54872	6.1644	93	10.7527	8649	804357	9.6437
39	25.6410	1521	59319	6.2450	94	10.6383	8836	830584	9.6954
40	25.0000	1600	64000	6.3246	**95**	10.5263	9025	857375	9.7468
41	24.3902	1681	68921	6.4031	96	10.4167	9216	884736	9.7980
42	23.8095	1764	74088	6.4807	97	10.3093	9409	912673	9.8489
43	23.2558	1849	79507	6.5574	98	10.2041	9604	941192	9.8995
44	22.7273	1936	85184	6.6332	99	10.1010	9801	970299	9.9499
45	22.2222	2025	91125	6.7082	**100**	10.0000	10000	1000000	10.0000
46	21.7391	2116	97336	6.7823	101	9.90099	10201	1030301	10.0499
47	21.2766	2209	103823	6.8557	102	9.80392	10404	1061208	10.0995
48	20.8333	2304	110592	6.9282	103	9.70874	10609	1092727	10.1489
49	20.4082	2401	117649	7.0000	104	9.61538	10816	1124864	10.1980
50	20.0000	2500	125000	7.0711	**105**	9.52381	11025	1157625	10.2470
51	19.6078	2601	132651	7.1414	106	9.43396	11236	1191016	10.2956
52	19.2308	2704	140608	7.2111	107	9.34579	11449	1225043	10.3441
53	18.8679	2809	148877	7.2801	108	9.25926	11664	1259712	10.3923
54	18.5185	2916	157464	7.3485	109	9.17431	11881	1295029	10.4403
55	18.1818	3025	166375	7.4162	**110**	9.09091	12100	1331000	10.4881
56	17.8571	3136	175616	7.4833	111	9.00901	12321	1367631	10.5357
57	17.5439	3249	185193	7.5498	112	8.92857	12544	1404928	10.5830
58	17.2414	3364	195112	7.6158	113	8.84956	12769	1442897	10.6301
59	16.9492	3481	205379	7.6811	114	8.77193	12996	1481544	10.6771
60	16.6667	3600	216000	7.7460	**115**	8.69565	13225	1520875	10.7238
61	16.3934	3721	226981	7.8102	116	8.62069	13456	1560896	10.7703
62	16.1290	3844	238328	7.8740	117	8.54701	13689	1601613	10.8167
63	15.8730	3969	250047	7.9373	118	8.47458	13924	1643032	10.8628
64	15.6250	4096	262144	8.0000	119	8.40336	14161	1685159	10.9087

TABLE 6 (*continued*).

VALUES OF RECIPROCALS, SQUARES, CUBES, SQUARE ROOTS, OF NATURAL NUMBERS.

n	$1000.\frac{1}{n}$	n^2	n^3	$\sqrt{n}$	n	$1000.\frac{1}{n}$	n^2	n^3	$\sqrt{n}$
120	8.33333	14400	1728000	10.9545	**175**	5.71429	30625	5359375	13.2288
121	8.26446	14641	1771561	11.0000	176	5.68182	30976	5451776	13.2665
122	8.19672	14884	1815848	11.0454	177	5.64972	31329	5545233	13.3041
123	8.13008	15129	1860867	11.0905	178	5.61798	31684	5639752	13.3417
124	8.06452	15376	1906624	11.1355	179	5.58659	32041	5735339	13.3791
125	8.00000	15625	1953125	11.1803	**180**	5.55556	32400	5832000	13.4164
126	7.93651	15876	2000376	11.2250	181	5.52486	32761	5929741	13.4536
127	7.87402	16129	2048383	11.2694	182	5.49451	33124	6028568	13.4907
128	7.81250	16384	2097152	11.3137	183	5.46448	33489	6128487	13.5277
129	7.75194	16641	2146689	11.3578	184	5.43478	33856	6229504	13.5647
130	7.69231	16900	2197000	11.4018	**185**	5.40541	34225	6331625	13.6015
131	7.63359	17161	2248091	11.4455	186	5.37634	34596	6434856	13.6382
132	7.57576	17424	2299968	11.4891	187	5.34759	34969	6539203	13.6748
133	7.51880	17689	2352637	11.5326	188	5.31915	35344	6644672	13.7113
134	7.46269	17956	2406104	11.5758	189	5.29101	35721	6751269	13.7477
135	7.40741	18225	2460375	11.6190	**190**	5.26316	36100	6859000	13.7840
136	7.35294	18496	2515456	11.6619	191	5.23560	36481	6967871	13.8203
137	7.29927	18769	2571353	11.7047	192	5.20833	36864	7077888	13.8564
138	7.24638	19044	2628072	11.7473	193	5.18135	37249	7189057	13.8924
139	7.19424	19321	2685619	11.7898	194	5.15464	37636	7301384	13.9284
140	7.14286	19600	2744000	11.8322	**195**	5.12821	38025	7414875	13.9642
141	7.09220	19881	2803221	11.8743	196	5.10204	38416	7529536	14.0000
142	7.04225	20164	2863288	11.9164	197	5.07614	38809	7645373	14.0357
143	6.99301	20449	2924207	11.9583	198	5.05051	39204	7762392	14.0712
144	6.94444	20736	2985984	12.0000	199	5.02513	39601	7880599	14.1067
145	6.89655	21025	3048625	12.0416	**200**	5.00000	40000	8000000	14.1421
146	6.84932	21316	3112136	12.0830	201	4.97512	40401	8120601	14.1774
147	6.80272	21609	3176523	12.1244	202	4.95050	40804	8242408	14.2127
148	6.75676	21904	3241792	12.1655	203	4.92611	41209	8365427	14.2478
149	6.71141	22201	3307949	12.2066	204	4.90196	41616	8489664	14.2829
150	6.66667	22500	3375000	12.2474	**205**	4.87805	42025	8615125	14.3178
151	6.62252	22801	3442951	12.2882	206	4.85437	42436	8741816	14.3527
152	6.57895	23104	3511808	12.3288	207	4.83092	42849	8869743	14.3875
153	6.53595	23409	3581577	12.3693	208	4.80769	43264	8998912	14.4222
154	6.49351	23716	3652264	12.4097	209	4.78469	43681	9129329	14.4568
155	6.45161	24025	3723875	12.4499	**210**	4.76190	44100	9261000	14.4914
156	6.41026	24336	3796416	12.4900	211	4.73934	44521	9393931	14.5258
157	6.36943	24649	3869893	12.5300	212	4.71698	44944	9528128	14.5602
158	6.32911	24964	3944312	12.5698	213	4.69484	45369	9663597	14.5945
159	6.28931	25281	4019679	12.6095	214	4.67290	45796	9800344	14.6287
160	6.25000	25600	4096000	12.6491	**215**	4.65116	46225	9938375	14.6629
161	6.21118	25921	4173281	12.6886	216	4.62963	46656	10077696	14.6969
162	6.17284	26244	4251528	12.7279	217	4.60829	47089	10218313	14.7309
163	6.13497	26569	4330747	12.7671	218	4.58716	47524	10360232	14.7648
164	6.09756	26896	4410944	12.8062	219	4.56621	47961	10503459	14.7986
165	6.06061	27225	4492125	12.8452	**220**	4.54545	48400	10648000	14.8324
166	6.02410	27556	4574296	12.8841	221	4.52489	48841	10793861	14.8661
167	5.98802	27889	4657463	12.9228	222	4.50450	49284	10941048	14.8997
168	5.95238	28224	4741632	12.9615	223	4.48431	49729	11089567	14.9332
169	5.91716	28561	4826809	13.0000	224	4.46429	50176	11239424	14.9666
170	5.88235	28900	4913000	13.0384	**225**	4.44444	50625	11390625	15.0000
171	5.84795	29241	5000211	13.0767	226	4.42478	51076	11543176	15.0333
172	5.81395	29584	5088448	13.1149	227	4.40529	51529	11697083	15.0665
173	5.78035	29929	5177717	13.1529	228	4.38596	51984	11852352	15.0997
174	5.74713	30276	5268024	13.1909	229	4.36681	52441	12008989	15.1327

TABLE 6 (*continued*).

VALUES OF RECIPROCALS, SQUARES, CUBES, AND SQUARE ROOTS, OF NATURAL NUMBERS.

n	$1000.\frac{1}{n}$	n^2	n^3	$\sqrt{n}$	n	$1000.\frac{1}{n}$.	n^2	n^3	$\sqrt{n}$
230	4.34783	52900	12167000	15.1658	**285**	3.50877	81225	23149125	16.8819
231	4.32900	53361	12326391	15.1987	286	3.49650	81796	23393656	16.9115
232	4.31034	53824	12487168	15.2315	287	3.48432	82369	23639903	16.9411
233	4.29185	54289	12649337	15.2643	288	3.47222	82944	23887872	16.9706
234	4.27350	54756	12812904	15.2971	289	3.46021	83521	24137569	17.0000
235	4.25532	55225	12977875	15.3297	**290**	3.44828	84100	24389000	17.0294
236	4.23729	55696	13144256	15.3623	291	3.43643	84681	24642171	17.0587
237	4.21941	56169	13312053	15.3948	292	3.42466	85264	24897088	17.0880
238	4.20168	56644	13481272	15.4272	293	3.41297	85849	25153757	17.1172
239	4.18410	57121	13651919	15.4596	294	3.40136	86436	25412184	17.1464
240	4.16667	57600	13824000	15.4919	**295**	3.38983	87025	25672375	17.1756
241	4.14938	58081	13997521	15.5242	296	3.37838	87616	25934336	17.2047
242	4.13223	58564	14172488	15.5563	297	3.36700	88209	26198073	17.2337
243	4.11523	59049	14348907	15.5885	298	3.35570	88804	26463592	17.2627
244	4.09836	59536	14526784	15.6205	299	3.34448	89401	26730899	17.2916
245	4.08163	60025	14706125	15.6525	**300**	3.33333	90000	27000000	17.3205
246	4.06504	60516	14886936	15.6844	301	3.32226	90601	27270901	17.3494
247	4.04858	61009	15069223	15.7162	302	3.31126	91204	27543608	17.3781
248	4.03226	61504	15252992	15.7480	303	3.30033	91809	27818127	17.4069
249	4.01606	62001	15438249	15.7797	304	3.28947	92416	28094464	17.4356
250	4.00000	62500	15625000	15.8114	**305**	3.27869	93025	28372625	17.4642
251	3.98406	63001	15813251	15.8430	306	3.26797	93636	28652616	17.4929
252	3.96825	63504	16003008	15.8745	307	3.25733	94249	28934443	17.5214
253	3.95257	64009	16194277	15.9060	308	3.24675	94864	29218112	17.5499
254	3.93701	64516	16387064	15.9374	309	3.23625	95481	29503629	17.5784
255	3.92157	65025	16581375	15.9687	**310**	3.22581	96100	29791000	17.6068
256	3.90625	65536	16777216	16.0000	311	3.21543	96721	30080231	17.6352
257	3.89105	66049	16974593	16.0312	312	3.20513	97344	30371328	17.6635
258	3.87597	66564	17173512	16.0624	313	3.19489	97969	30664297	17.6918
259	3.86100	67081	17373979	16.0935	314	3.18471	98596	30959144	17.7200
260	3.84615	67600	17576000	16.1245	**315**	3.17460	99225	31255875	17.7482
261	3.83142	68121	17779581	16.1555	316	3.16456	99856	31554496	17.7764
262	3.81679	68644	17984728	16.1864	317	3.15457	100489	31855013	17.8045
263	3.80228	69169	18191447	16.2173	318	3.14465	101124	32157432	17.8326
264	3.78788	69696	18399744	16.2481	319	3.13480	101761	32461759	17.8606
265	3.77358	70225	18609625	16.2788	**320**	3.12500	102400	32768000	17.8885
266	3.75940	70756	18821096	16.3095	321	3.11527	103041	33076161	17.9165
267	3.74532	71289	19034163	16.3401	322	3.10559	103684	33386248	17.9444
268	3.73134	71824	19248832	16.3707	323	3.09598	104329	33698267	17.9722
269	3.71747	72361	19465109	16.4012	324	3.08642	104976	34012224	18.0000
270	3.70370	72900	19683000	16.4317	**325**	3.07692	105625	34328125	18.0278
271	3.69004	73441	19902511	16.4621	326	3.06748	106276	34645976	18.0555
272	3.67647	73984	20123648	16.4924	327	3.05810	106929	34965783	18.0831
273	3.66300	74529	20346417	16.5227	328	3.04878	107584	35287552	18.1108
274	3.64964	75076	20570824	16.5529	329	3.03951	108241	35611289	18.1384
275	3.63636	75625	20796875	16.5831	**330**	3.03030	108900	35937000	18.1659
276	3.62319	76176	21024576	16.6132	331	3.02115	109561	36264691	18.1934
277	3.61011	76729	21253933	16.6433	332	3.01205	110224	36594368	18.2209
278	3.59712	77284	21484952	16.6733	333	3.00300	110889	36926037	18.2483
279	3.58423	77841	21717639	16.7033	334	2.99401	111556	37259704	18.2757
280	3.57143	78400	21952000	16.7332	**335**	2.98507	112225	37595375	18.3030
281	3.55872	78961	22188041	16.7631	336	2.97619	112896	37933056	18.3303
282	3.54610	79524	22425768	16.7929	337	2.96736	113569	38272753	18.3576
283	3.53357	80089	22665187	16.8226	338	2.95858	114244	38614472	18.3848
284	3.52113	80656	22906304	16.8523	339	2.94985	114921	38958219	18.4120

TABLE 6 (*continued*).

VALUES OF RECIPROCALS, SQUARES, CUBES, AND SQUARE ROOTS OF NATURAL NUMBERS.

n	$1000.\frac{1}{n}$	n^2	n^3	$\sqrt{n}$	n	$1000.\frac{1}{n}$	n^2	n^3	$\sqrt{n}$
340	2.94118	115600	39304000	18.4391	**395**	2.53165	156025	61629875	19.8746
341	2.93255	116281	39651821	18.4662	396	2.52525	156816	62099136	19.8997
342	2.92398	116964	40001688	18.4932	397	2.51889	157609	62570773	19.9249
343	2.91545	117649	40353607	18.5203	398	2.51256	158404	63044792	19.9499
344	2.90698	118336	40707584	18.5472	399	2.50627	159201	63521199	19.9750
345	2.89855	119025	41063625	18.5742	**400**	2.50000	160000	64000000	20.0000
346	2.89017	119716	41421736	18.6011	401	2.49377	160801	64481201	20.0250
347	2.88184	120409	41781923	18.6279	402	2.48756	161604	64964808	20.0499
348	2.87356	121104	42144192	18.6548	403	2.48139	162409	65450827	20.0749
349	2.86533	121801	42508549	18.6815	404	2.47525	163216	65939264	20.0998
350	2.85714	122500	42875000	18.7083	**405**	2.46914	164025	66430125	20.1246
351	2.84900	123201	43243551	18.7350	406	2.46305	164836	66923416	20.1494
352	2.84091	123904	43614208	18.7617	407	2.45700	165649	67419143	20.1742
353	2.83286	124609	43986977	18.7883	408	2.45098	166464	67917312	20.1990
354	2.82486	125316	44361864	18.8149	409	2.44499	167281	68417929	20.2237
355	2.81690	126025	44738875	18.8414	**410**	2.43902	168100	68921000	20.2485
356	2.80899	126736	45118016	18.8680	411	2.43309	168921	69426531	20.2731
357	2.80112	127449	45499293	18.8944	412	2.42718	169744	69934528	20.2978
358	2.79330	128164	45882712	18.9209	413	2.42131	170569	70444997	20.3224
359	2.78552	128881	46268279	18.9473	414	2.41546	171396	70957944	20.3470
360	2.77778	129600	46656000	18.9737	**415**	2.40964	172225	71473375	20.3715
361	2.77008	130321	47045881	19.0000	416	2.40385	173056	71991296	20.3961
362	2.76243	131044	47437928	19.0263	417	2.39808	173889	72511713	20.4206
363	2.75482	131769	47832147	19.0526	418	2.39234	174724	73034632	20.4450
364	2.74725	132496	48228544	19.0788	419	2.38663	175561	73560059	20.4695
365	2.73973	133225	48627125	19.1050	**420**	2.38095	176400	74088000	20.4939
366	2.73224	133956	49027896	19.1311	421	2.37530	177241	74618461	20.5183
367	2.72480	134689	49430863	19.1572	422	2.36967	178084	75151448	20.5426
368	2.71739	135424	49836032	19.1833	423	2.36407	178929	75686967	20.5670
369	2.71003	136161	50243409	19.2094	424	2.35849	179776	76225024	20.5913
370	2.70270	136900	50653000	19.2354	**425**	2.35294	180625	76765625	20.6155
371	2.69542	137641	51064811	19.2614	426	2.34742	181476	77308776	20.6398
372	2.68817	138384	51478848	19.2873	427	2.34192	182329	77854483	20.6640
373	2.68097	139129	51895117	19.3132	428	2.33645	183184	78402752	20.6882
374	2.67380	139876	52313624	19.3391	429	2.33100	184041	78953589	20.7123
375	2.66667	140625	52734375	19.3649	**430**	2.32558	184900	79507000	20.7364
376	2.65957	141376	53157376	19.3907	431	2.32019	185761	80062991	20.7605
377	2.65252	142129	53582633	19.4165	432	2.31481	186624	80621568	20.7846
378	2.64550	142884	54010152	19.4422	433	2.30947	187489	81182737	20.8087
379	2.63852	143641	54439939	19.4679	434	2.30415	188356	81746504	20.8327
380	2.63158	144400	54872000	19.4936	**435**	2.29885	189225	82312875	20.8567
381	2.62467	145161	55306341	19.5192	436	2.29358	190096	82881856	20.8806
382	2.61780	145924	55742968	19.5448	437	2.28833	190969	83453453	20.9045
383	2.61097	146689	56181887	19.5704	438	2.28311	191844	84027672	20.9284
384	2.60417	147456	56623104	19.5959	439	2.27790	192721	84604519	20.9523
385	2.59740	148225	57066625	19.6214	**440**	2.27273	193600	85184000	20.9762
386	2.59067	148996	57512456	19.6469	441	2.26757	194481	85766121	21.0000
387	2.58398	149769	57960603	19.6723	442	2.26244	195364	86350888	21.0238
388	2.57732	150544	58411072	19.6977	443	2.25734	196249	86938307	21.0476
389	2.57069	151321	58863869	19.7231	444	2.25225	197136	87528384	21.0713
390	2.56410	152100	59319000	19.7484	**445**	2.24719	198025	88121125	21.0950
391	2.55754	152881	59776471	19.7737	446	2.24215	198916	88716536	21.1187
392	2.55102	153664	60236288	19.7990	447	2.23714	199809	89314623	21.1424
393	2.54453	154449	60698457	19.8242	448	2.23214	200704	89915392	21.1660
394	2.53807	155236	61162984	19.8494	449	2.22717	201601	90518849	21.1896

TABLE 6 (*continued*).

VALUES OF RECIPROCALS, SQUARES, CUBES, AND SQUARE ROOTS OF NATURAL NUMBERS.

n	$1000.\frac{1}{n}$	n^2	n^3	$\sqrt{n}$	n	$1000.\frac{1}{n}$	n^2	n^3	$\sqrt{n}$
450	2.22222	202500	91125000	21.2132	**505**	1.98020	255025	128787625	22.4722
451	2.21730	203401	91733851	21.2368	506	1.97628	256036	129554216	22.4944
452	2.21239	204304	92345408	21.2603	507	1.97239	257049	130323843	22.5167
453	2.20751	205209	92959677	21.2838	508	1.96850	258064	131096512	22.5389
454	2.20264	206116	93576664	21.3073	509	1.96464	259081	131872229	22.5610
455	2.19780	207025	94196375	21.3307	**510**	1.96078	260100	132651000	22.5832
456	2.19298	207936	94818816	21.3542	511	1.95695	261121	133432831	22.6053
457	2.18818	208849	95443993	21.3776	512	1.95312	262144	134217728	22.6274
458	2.18341	209764	96071912	21.4009	513	1.94932	263169	135005697	22.6495
459	2.17865	210681	96702579	21.4243	514	1.94553	264196	135796744	22.6716
460	2.17391	211600	97336000	21.4476	**515**	1.94175	265225	136590875	22.6936
461	2.16920	212521	97972181	21.4709	516	1.93798	266256	137388096	22.7156
462	2.16450	213444	98611128	21.4942	517	1.93424	267289	138188413	22.7376
463	2.15983	214369	99252847	21.5174	518	1.93050	268324	138991832	22.7596
464	2.15517	215296	99897344	21.5407	519	1.92678	269361	139798359	22.7816
465	2.15054	216225	100544625	21.5639	**520**	1.92308	270400	140608000	22.8035
466	2.14592	217156	101194696	21.5870	521	1.91939	271441	141420761	22.8254
467	2.14133	218089	101847563	21.6102	522	1.91571	272484	142236648	22.8473
468	2.13675	219024	102503232	21.6333	523	1.91205	273529	143055667	22.8692
469	2.13220	219961	103161709	21.6564	524	1.90840	274576	143877824	22.8910
470	2.12766	220900	103823000	21.6795	**525**	1.90476	275625	144703125	22.9129
471	2.12314	221841	104487111	21.7025	526	1.90114	276676	145531576	22.9347
472	2.11864	222784	105154048	21.7256	527	1.89753	277729	146363183	22.9565
473	2.11416	223729	105823817	21.7486	528	1.89394	278784	147197952	22.9783
474	2.10970	224676	106496424	21.7715	529	1.89036	279841	148035889	23.0000
475	2.10526	225625	107171875	21.7945	**530**	1.88679	280900	148877000	23.0217
476	2.10084	226576	107850176	21.8174	531	1.88324	281961	149721291	23.0434
477	2.09644	227529	108531333	21.8403	532	1.87970	283024	150568768	23.0651
478	2.09205	228484	109215352	21.8632	533	1.87617	284089	151419437	23.0868
479	2.08768	229441	109902239	21.8861	534	1.87266	285156	152273304	23.1084
480	2.08333	230400	110592000	21.9089	**535**	1.86916	286225	153130375	23.1301
481	2.07900	231361	111284641	21.9317	536	1.86567	287296	153990656	23.1517
482	2.07469	232324	111980168	21.9545	537	1.86220	288369	154854153	23.1733
483	2.07039	233289	112678587	21.9773	538	1.85874	289444	155720872	23.1948
484	2.06612	234256	113379904	22.0000	539	1.85529	290521	156590819	23.2164
485	2.06186	235225	114084125	22.0227	**540**	1.85185	291600	157464000	23.2379
486	2.05761	236196	114791256	22.0454	541	1.84843	292681	158340421	23.2594
487	2.05339	237169	115501303	22.0681	542	1.84502	293764	159220088	23.2809
488	2.04918	238144	116214272	22.0907	543	1.84162	294849	160103007	23.3024
489	2.04499	239121	116930169	22.1133	544	1.83824	295936	160989184	23.3238
490	2.04082	240100	117649000	22.1359	**545**	1.83486	297025	161878625	23.3452
491	2.03666	241081	118370771	22.1585	546	1.83150	298116	162771336	23.3666
492	2.03252	242064	119095488	22.1811	547	1.82815	299209	163667323	23.3880
493	2.02840	243049	119823157	22.2036	548	1.82482	300304	164566592	23.4094
494	2.02429	244036	120553784	22.2261	549	1.82149	301401	165469149	23.4307
495	2.02020	245025	121287375	22.2486	**550**	1.81818	302500	166375000	23.4521
496	2.01613	246016	122023936	22.2711	551	1.81488	303601	167284151	23.4734
497	2.01207	247009	122763473	22.2935	552	1.81159	304704	168196608	23.4947
498	2.00803	248004	123505992	22.3159	553	1.80832	305809	169112377	23.5160
499	2.00401	249001	124251499	22.3383	554	1.80505	306916	170031464	23.5372
500	2.00000	250000	125000000	22.3607	**555**	1.80180	308025	170953875	23.5584
501	1.99601	251001	125751501	22.3830	556	1.79856	309136	171879616	23.5797
502	1.99203	252004	126506008	22.4054	557	1.79533	310249	172808693	23.6008
503	1.98807	253009	127263527	22.4277	558	1.79211	311364	173741112	23.6220
504	1.98413	254016	128024064	22.4499	559	1.78891	312481	174676879	23.6432

TABLE 6 (*continued*).

VALUES OF RECIPROCALS, SQUARES, CUBES, AND SQUARE ROOTS OF NATURAL NUMBERS.

n	$1000.\frac{1}{n}$	n^2	n^3	$\sqrt{n}$	n	$1000.\frac{1}{n}$	n^2	n^3	$\sqrt{n}$
560	1.78571	313600	175616000	23.6643	**615**	1.62602	378225	232608375	24.7992
561	1.78253	314721	176558481	23.6854	616	1.62338	379456	233744896	24.8193
562	1.77936	315844	177504328	23.7065	617	1.62075	380689	234885113	24.8395
563	1.77620	316969	178453547	23.7276	618	1.61812	381924	236029032	24.8596
564	1.77305	318096	179406144	23.7487	619	1.61551	383161	237176659	24.8797
565	1.76991	319225	180362125	23.7697	**620**	1.61290	384400	238328000	24.8998
566	1.76678	320356	181321496	23.7908	621	1.61031	385641	239483061	24.9199
567	1.76367	321489	182284263	23.8118	622	1.60772	386884	240641848	24.9399
568	1.76056	322624	183250432	23.8328	623	1.60514	388129	241804367	24.9600
569	1.75747	323761	184220009	23.8537	624	1.60256	389376	242970624	24.9800
570	1.75439	324900	185193000	23.8747	**625**	1.60000	390625	244140625	25.0000
571	1.75131	326041	186169411	23.8956	626	1.59744	391876	245314376	25.0200
572	1.74825	327184	187149248	23.9165	627	1.59490	393129	246491883	25.0400
573	1.74520	328329	188132517	23.9374	628	1.59236	394384	247673152	25.0599
574	1.74216	329476	189119224	23.9583	629	1.58983	395641	248858189	25.0799
575	1.73913	330625	190109375	23.9792	**630**	1.58730	396900	250047000	25.0998
576	1.73611	331776	191102976	24.0000	631	1.58479	398161	251239591	25.1197
577	1.73310	332929	192100033	24.0208	632	1.58228	399424	252435968	25.1396
578	1.73010	334084	193100552	24.0416	633	1.57978	400689	253636137	25.1595
579	1.72712	335241	194104539	24.0624	634	1.57729	401956	254840104	25.1794
580	1.72414	336400	195112000	24.0832	**635**	1.57480	403225	256047875	25.1992
581	1.72117	337561	196122941	24.1039	636	1.57233	404496	257259456	25.2190
582	1.71821	338724	197137368	24.1247	637	1.56986	405769	258474853	25.2389
583	1.71527	339889	198155287	24.1454	638	1.56740	407044	259694072	25.2587
584	1.71233	341056	199176704	24.1661	639	1.56495	408321	260917119	25.2784
585	1.70940	342225	200201625	24.1868	**640**	1.56250	409600	262144000	25.2982
586	1.70648	343396	201230056	24.2074	641	1.56006	410881	263374721	25.3180
587	1.70358	344569	202262003	24.2281	642	1.55763	412164	264609288	25.3377
588	1.70068	345744	203297472	24.2487	643	1.55521	413449	265847707	25.3574
589	1.69779	346921	204336469	24.2693	644	1.55280	414736	267089984	25.3772
590	1.69492	348100	205379000	24.2899	**645**	1.55039	416025	268336125	25.3969
591	1.69205	349281	206425071	24.3105	646	1.54799	417316	269586136	25.4165
592	1.68919	350464	207474688	24.3311	647	1.54560	418609	270840023	25.4362
593	1.68634	351649	208527857	24.3516	648	1.54321	419904	272097792	25.4558
594	1.68350	352836	209584584	24.3721	649	1.54083	421201	273359449	25.4755
595	1.68067	354025	210644875	24.3926	**650**	1.53846	422500	274625000	25.4951
596	1.67785	355216	211708736	24.4131	651	1.53610	423801	275894451	25.5147
597	1.67504	356409	212776173	24.4336	652	1.53374	425104	277167808	25.5343
598	1.67224	357604	213847192	24.4540	653	1.53139	426409	278445077	25.5539
599	1.66945	358801	214921799	24.4745	654	1.52905	427716	279726264	25.5734
600	1.66667	360000	216000000	24.4949	**655**	1.52672	429025	281011375	25.5930
601	1.66389	361201	217081801	24.5153	656	1.52439	430336	282300416	25.6125
602	1.66113	362404	218167208	24.5357	657	1.52207	431649	283593393	25.6320
603	1.65837	363609	219256227	24.5561	658	1.51976	432964	284890312	25.6515
604	1.65563	364816	220348864	24.5764	659	1.51745	434281	286191179	25.6710
605	1.65289	366025	221445125	24.5967	**660**	1.51515	435600	287496000	25.6905
606	1.65017	367236	222545016	24.6171	661	1.51286	436921	288804781	25.7099
607	1.64745	368449	223648543	24.6374	662	1.51057	438244	290117528	25.7294
608	1.64474	369664	224755712	24.6577	663	1.50830	439569	291434247	25.7488
609	1.64204	370881	225866529	24.6779	664	1.50602	440896	292754944	25.7682
610	1.63934	372100	226981000	24.6982	**665**	1.50376	442225	294079625	25.7876
611	1.63666	373321	228099131	24.7184	666	1.50150	443556	295408296	25.8070
612	1.63399	374544	229220928	24.7386	667	1.49925	444889	296740963	25.8263
613	1.63132	375769	230346397	24.7588	668	1.49701	446224	298077632	25.8457
614	1.62866	376996	231475544	24.7790	669	1.49477	447561	299418309	25.8650

TABLE 6 (*continued*).

VALUES OF RECIPROCALS, SQUARES, CUBES, AND SQUARE ROOTS OF NATURAL NUMBERS.

n	$1000.\frac{1}{n}$	n^2	n^3	$\sqrt{n}$	n	$1000.\frac{1}{n}$	n^2	n^3	$\sqrt{n}$
670	1.49254	448900	300763000	25.8844	**725**	1.37931	525625	381078125	26.9258
671	1.49031	450241	302111711	25.9037	726	1.37741	527076	382657176	26.9444
672	1.48810	451584	303464448	25.9230	727	1.37552	528529	384240583	26.9629
673	1.48588	452929	304821217	25.9422	728	1.37363	529984	385828352	26.9815
674	1.48368	454276	306182024	25.9615	729	1.37174	531441	387420489	27.0000
675	1.48148	455625	307546875	25.9808	**730**	1.36986	532900	389017000	27.0185
676	1.47929	456976	308915776	26.0000	731	1.36799	534361	390617891	27.0370
677	1.47710	458329	310288733	26.0192	732	1.36612	535824	392223168	27.0555
678	1.47493	459684	311665752	26.0384	733	1.36426	537289	393832837	27.0740
679	1.47275	461041	313046839	26.0576	734	1.36240	538756	395446904	27.0924
680	1.47059	462400	314432000	26.0768	**735**	1.36054	540225	397065375	27.1109
681	1.46843	463761	315821241	26.0960	736	1.35870	541696	398688256	27.1293
682	1.46628	465124	317214568	26.1151	737	1.35685	543169	400315553	27.1477
683	1.46413	466489	318611987	26.1343	738	1.35501	544644	401947272	27.1662
684	1.46199	467856	320013504	26.1534	739	1.35318	546121	403583419	27.1846
685	1.45985	469225	321419125	26.1725	**740**	1.35135	547600	405224000	27.2029
686	1.45773	470596	322828856	26.1916	741	1.34953	549081	406869021	27.2213
687	1.45560	471969	324242703	26.2107	742	1.34771	550564	408518488	27.2397
688	1.45349	473344	325660672	26.2298	743	1.34590	552049	410172407	27.2580
689	1.45138	474721	327082769	26.2488	744	1.34409	553536	411830784	27.2764
690	1.44928	476100	328509000	26.2679	**745**	1.34228	555025	413493625	27.2947
691	1.44718	477481	329939371	26.2869	746	1.34048	556516	415160936	27.3130
692	1.44509	478864	331373888	26.3059	747	1.33869	558009	416832723	27.3313
693	1.44300	480249	332812557	26.3249	748	1.33690	559504	418508992	27.3496
694	1.44092	481636	334255384	26.3439	749	1.33511	561001	420189749	27.3679
695	1.43885	483025	335702375	26.3629	**750**	1.33333	562500	421875000	27.3861
696	1.43678	484416	337153536	26.3818	751	1.33156	564001	423564751	27.4044
697	1.43472	485809	338608873	26.4008	752	1.32979	565504	425259008	27.4226
698	1.43266	487204	340368392	26.4197	753	1.32802	567009	426957777	27.4408
699	1.43062	488601	341532099	26.4386	754	1.32626	568516	428661064	27.4591
700	1.42857	490000	343000000	26.4575	**755**	1.32450	570025	430368875	27.4773
701	1.42653	491401	344472101	26.4764	756	1.32275	571536	432081216	27.4955
702	1.42450	492804	345948408	26.4953	757	1.32100	573049	433798093	27.5136
703	1.42248	494209	347428927	26.5141	758	1.31926	574564	435519512	27.5318
704	1.42045	495616	348913664	26.5330	759	1.31752	576081	437245479	27.5500
705	1.41844	497025	350402625	26.5518	**760**	1.31579	577600	438976000	27.5681
706	1.41643	498436	351895816	26.5707	761	1.31406	579121	440711081	27.5862
707	1.41443	499849	353393243	26.5895	762	1.31234	580644	442450728	27.6043
708	1.41243	501264	354894912	26.6083	763	1.31062	582169	444194947	27.6225
709	1.41044	502681	356400829	26.6271	764	1.30890	583696	445943744	27.6405
710	1.40845	504100	357911000	26.6458	**765**	1.30719	585225	447697125	27.6586
711	1.40647	505521	359425431	26.6646	766	1.30548	586756	449455096	27.6767
712	1.40449	506944	360944128	26.6833	767	1.30378	588289	451217663	27.6948
713	1.40252	508369	362467097	26.7021	768	1.30208	589824	452984832	27.7128
714	1.40056	509796	363994344	26.7208	769	1.30039	591361	454756609	27.7308
715	1.39860	511225	365525875	26.7395	**770**	1.29870	592900	456533000	27.7489
716	1.39665	512656	367061696	26.7582	771	1.29702	594441	458314011	27.7669
717	1.39470	514089	368601813	26.7769	772	1.29534	595984	460099648	27.7849
718	1.39276	515524	370146232	26.7955	773	1.29366	597529	461889917	27.8029
719	1.39082	516961	371694959	26.8142	774	1.29199	599076	463684824	27.8209
720	1.38889	518400	373248000	26.8328	**775**	1.29032	600625	465484375	27.8388
721	1.38696	519841	374805361	26.8514	776	1.28866	602176	467288576	27.8568
722	1.38504	521284	376367048	26.8701	777	1.28700	603729	469097433	27.8747
723	1.38313	522729	377933067	26.8887	778	1.28535	605284	470910952	27.8927
724	1.38122	524176	379503424	26.9072	779	1.28370	606841	472729139	27.9106

VALUES OF RECIPROCALS, SQUARES, CUBES, AND SQUARE ROOTS OF NATURAL NUMBERS.

n	$1000.\frac{1}{n}$	n^2	n^3	$\sqrt{n}$	n	$1000.\frac{1}{n}$	n^2	n^3	$\sqrt{n}$
780	1.28205	608400	474552000	27.9285	**835**	1.19760	697225	582182875	28.8964
781	1.28041	609961	476379541	27.9464	836	1.19617	698896	584277056	28.9137
782	1.27877	611524	478211768	27.9643	837	1.19474	700569	586376253	28.9310
783	1.27714	613089	480048687	27.9821	838	1.19332	702244	588480472	28.9482
784	1.27551	614656	481890304	28.0000	839	1.19190	703921	590589719	28.9655
785	1.27389	616225	483736625	28.0179	**840**	1.19048	705600	592704000	28.9828
786	1.27226	617796	485587656	28.0357	841	1.18906	707281	594823321	29.0000
787	1.27065	619369	487443403	28.0535	842	1.18765	708964	596947688	29.0172
788	1.26904	620944	489303872	28.0713	843	1.18624	710649	599077107	29.0345
789	1.26743	622521	491169069	28.0891	844	1.18483	712336	601211584	29.0517
790	1.26582	624100	493039000	28.1069	**845**	1.18343	714025	603351125	29.0689
791	1.26422	625681	494913671	28.1247	846	1.18203	715716	605495736	29.0861
792	1.26263	627264	496793088	28.1425	847	1.18064	717409	607645423	29.1033
793	1.26103	628849	498677257	28.1603	848	1.17925	719104	609800192	29.1204
794	1.25945	630436	500566184	28.1780	849	1.17786	720801	611960049	29.1376
795	1.25786	632025	502459875	28.1957	**850**	1.17647	722500	614125000	29.1548
796	1.25628	633616	504358336	28.2135	851	1.17509	724201	616295051	29.1719
797	1.25471	635209	506261573	28.2312	852	1.17371	725904	618470208	29.1890
798	1.25313	636804	508169592	28.2489	853	1.17233	727609	620650477	29.2062
799	1.25156	638401	510082399	28.2666	854	1.17096	729316	622835864	29.2233
800	1.25000	640000	512000000	28.2843	**855**	1.16959	731025	625026375	29.2404
801	1.24844	641601	513922401	28.3019	856	1.16822	732736	627222016	29.2575
802	1.24688	643204	515849608	28.3196	857	1.16686	734449	629422793	29.2746
803	1.24533	644809	517781627	28.3373	858	1.16550	736164	631628712	29.2916
804	1.24378	646416	519718464	28.3549	859	1.16414	737881	633839779	29.3087
805	1.24224	648025	521660125	28.3725	**860**	1.16279	739600	636056000	29.3258
806	1.24069	649636	523606616	28.3901	861	1.16144	741321	638277381	29.3428
807	1.23916	651249	525557943	28.4077	862	1.16009	743044	640503928	29.3598
808	1.23762	652864	527514112	28.4253	863	1.15875	744769	642735647	29.3769
809	1.23609	654481	529475129	28.4429	864	1.15741	746496	644972544	29.3939
810	1.23457	656100	531441000	28.4605	**865**	1.15607	748225	647214625	29.4109
811	1.23305	657721	533411731	28.4781	866	1.15473	749956	649461896	29.4279
812	1.23153	659344	535387328	28.4956	867	1.15340	751689	651714363	29.4449
813	1.23001	660969	537367797	28.5132	868	1.15207	753424	653972032	29.4618
814	1.22850	662596	539353144	28.5307	869	1.15075	755161	656234909	29.4788
815	1.22699	664225	541343375	28.5482	**870**	1.14943	756900	658503000	29.4958
816	1.22549	665856	543338496	28.5657	871	1.14811	758641	660776311	29.5127
817	1.22399	667489	545338513	28.5832	872	1.14679	760384	663054848	29.5296
818	1.22249	669124	547343432	28.6007	873	1.14548	762129	665338617	29.5466
819	1.22100	670761	549353259	28.6182	874	1.14416	763876	667627624	29.5635
820	1.21951	672400	551368000	28.6356	**875**	1.14286	765625	669921875	29.5804
821	1.21803	674041	553387661	28.6531	876	1.14155	767376	672221376	29.5973
822	1.21655	675684	555412248	28.6705	877	1.14025	769129	674526133	29.6142
823	1.21507	677329	557441767	28.6880	878	1.13895	770884	676836152	29.6311
824	1.21359	678976	559476224	28.7054	879	1.13766	772641	679151439	29.6479
825	1.21212	680625	561515625	28.7228	**880**	1.13636	774400	681472000	29.6648
826	1.21065	682276	563559976	28.7402	881	1.13507	776161	683797841	29.6816
827	1.20919	683929	565609283	28.7576	882	1.13379	777924	686128968	29.6985
828	1.20773	685584	567663552	28.7750	883	1.13250	779689	688465387	29.7153
829	1.20627	687241	569722789	28.7924	884	1.13122	781456	690807104	29.7321
830	1.20482	688900	571787000	28.8097	**885**	1.12994	783225	693154125	29.7489
831	1.20337	690561	573856191	28.8271	886	1.12867	784996	695506456	29.7658
832	1.20192	692224	575930368	28.8444	887	1.12740	786769	697864103	29.7825
833	1.20048	693889	578009537	28.8617	888	1.12613	788544	700227072	29.7993
834	1.19904	695556	580093704	28.8791	889	1.12486	790321	702595369	29.8161

VALUES OF RECIPROCALS, SQUARES, CUBES, AND SQUARE ROOTS OF NATURAL NUMBERS.

n	$1000.\frac{1}{n}$	n^2	n^3	$\sqrt{n}$	n	$1000.\frac{1}{n}$	n^2	n^3	$\sqrt{n}$
890	1.12360	792100	704969000	29.8329	**945**	1.05820	893025	843908625	30.7409
891	1.12233	793881	707347971	29.8496	946	1.05708	894916	846590536	30.7571
892	1.12108	795664	709732288	29.8664	947	1.05597	896809	849278123	30.7734
893	1.11982	797449	712121957	29.8831	948	1.05485	898704	851971392	30.7896
894	1.11857	799236	714516984	29.8998	949	1.05374	900601	854670349	30.8058
895	1.11732	801025	716917375	29.9166	**950**	1.05263	902500	857375000	30.8221
896	1.11607	802816	719323136	29.9333	951	1.05152	904401	860085351	30.8383
897	1.11483	804609	721734273	29.9500	952	1.05042	906304	862801408	30.8545
898	1.11359	806404	724150792	29.9666	953	1.04932	908209	865523177	30.8707
899	1.11235	808201	726572699	29.9833	954	1.04822	910116	868250664	30.8869
900	1.11111	810000	729000000	30.0000	**955**	1.04712	912025	870983875	30.9031
901	1.10988	811801	731432701	30.0167	956	1.04603	913936	873722816	30.9192
902	1.10865	813604	733870808	30.0333	957	1.04493	915849	876467493	30.9354
903	1.10742	815409	736314327	30.0500	958	1.04384	917764	879217912	30.9516
904	1.10619	817216	738763264	30.0666	959	1.04275	919681	881974079	30.9677
905	1.10497	819025	741217625	30.0832	**960**	1.04167	921600	884736000	30.9839
906	1.10375	820836	743677416	30.0998	961	1.04058	923521	887503681	31.0000
907	1.10254	822649	746142643	30.1164	962	1.03950	925444	890277128	31.0161
908	1.10132	824464	748613312	30.1330	963	1.03842	927369	893056347	31.0322
909	1.10011	826281	751089429	30.1496	964	1.03734	929296	895841344	31.0483
910	1.09890	828100	753571000	30.1662	**965**	1.03627	931225	898632125	31.0644
911	1.09769	829921	756058031	30.1828	966	1.03520	933156	901428696	31.0805
912	1.09649	831744	758550528	30.1993	967	1.03413	935089	904231063	31.0966
913	1.09529	833569	761048497	30.2159	968	1.03306	937024	907039232	31.1127
914	1.09409	835396	763551944	30.2324	969	1.03199	938961	909853209	31.1288
915	1.09290	837225	766060875	30.2490	**970**	1.03093	940900	912673000	31.1448
916	1.09170	839056	768575296	30.2655	971	1.02987	942841	915498611	31.1609
917	1.09051	840889	771095213	30.2820	972	1.02881	944784	918330048	31.1769
918	1.08932	842724	773620632	30.2985	973	1.02775	946729	921167317	31.1929
919	1.08814	844561	776151559	30.3150	974	1.02669	948676	924010424	31.2090
920	1.08696	846400	778688000	30.3315	**975**	1.02564	950625	926859375	31.2250
921	1.08578	848241	781229961	30.3480	976	1.02459	952576	929714176	31.2410
922	1.08460	850084	783777448	30.3645	977	1.02354	954529	932574833	31.2570
923	1.08342	851929	786330467	30.3809	978	1.02249	956484	935441352	31.2730
924	1.08225	853776	788889024	30.3974	979	1.02145	958441	938313739	31.2890
925	1.08108	855625	791453125	30.4138	**980**	1.02041	960400	941192000	31.3050
926	1.07991	857476	794022776	30.4302	981	1.01937	962361	944076141	31.3209
927	1.07875	859329	796597983	30.4467	982	1.01833	964324	946966168	31.3369
928	1.07759	861184	799178752	30.4631	983	1.01729	966289	949862087	31.3528
929	1.07643	863041	801765089	30.4795	984	1.01626	968256	952763904	31.3688
930	1.07527	864900	804357000	30.4959	**985**	1.01523	970225	955671625	31.3847
931	1.07411	866761	806954491	30.5123	986	1.01420	972196	958585256	31.4006
932	1.07296	868624	809557568	30.5287	987	1.01317	974169	961504803	31.4166
933	1.07181	870489	812166237	30.5450	988	1.01215	976144	964430272	31.4325
934	1.07066	872356	814780504	30.5614	989	1.01112	978121	967361669	31.4484
935	1.06952	874225	817400375	30.5778	**990**	1.01010	980100	970299000	31.4643
936	1.06838	876096	820025856	30.5941	991	1.00908	982081	973242271	31.4802
937	1.06724	877969	822656953	30.6105	992	1.00806	984064	976191488	31.4960
938	1.06610	879844	825293672	30.6268	993	1.00705	986049	979146657	31.5119
939	1.06496	881721	827936019	30.6431	994	1.00604	988036	982107784	31.5278
940	1.06383	883600	830584000	30.6594	**995**	1.00503	990025	985074875	31.5436
941	1.06270	885481	833237621	30.6757	996	1.00402	992016	988047936	31.5595
942	1.06157	887364	835896888	30.6920	997	1.00301	994009	991026973	31.5753
943	1.06045	889249	838561807	30.7083	998	1.00200	996004	994011992	31.5911
944	1.05932	891136	841232384	30.7246	999	1.00100	998001	997002999	31.6070

TABLE 7.

LOGARITHMS.

N.	0	1	2	3	4	5	6	7	8	9	10
100	0000	0004	0009	0013	0017	0022	0026	0030	0035	0039	0043
101	0043	0048	0052	0056	0060	0065	0069	0073	0077	0082	0086
102	0086	0090	0095	0099	0103	0107	0111	0116	0120	0124	0128
103	0128	0133	0137	0141	0145	0149	0154	0158	0162	0166	0170
104	0170	0175	0179	0183	0187	0191	0195	0199	0204	0208	0212
105	0212	0216	0220	0224	0228	0233	0237	0241	0245	0249	0253
106	0253	0257	0261	0265	0269	0273	0278	0282	0286	0290	0294
107	0294	0298	0302	0306	0310	0314	0318	0322	0326	0330	0334
108	0334	0338	0342	0346	0350	0354	0358	0362	0366	0370	0374
109	0374	0378	0382	0386	0390	0394	0398	0402	0406	0410	0414
110	0414	0418	0422	0426	0430	0434	0438	0441	0445	0449	0453
111	0453	0457	0461	0465	0469	0473	0477	0481	0484	0488	0492
112	0492	0496	0500	0504	0508	0512	0515	0519	0523	0527	0531
113	0531	0535	0538	0542	0546	0550	0554	0558	0561	0565	0569
114	0569	0573	0577	0580	0584	0588	0592	0596	0599	0603	0607
115	0607	0611	0615	0618	0622	0626	0630	0633	0637	0641	0645
116	0645	0648	0652	0656	0660	0663	0667	0671	0674	0678	0682
117	0682	0686	0689	0693	0697	0700	0704	0708	0711	0715	0719
118	0719	0722	0726	0730	0734	0737	0741	0745	0748	0752	0755
119	0755	0759	0763	0766	0770	0774	0777	0781	0785	0788	0792
120	0792	0795	0799	0803	0806	0810	0813	0817	0821	0824	0828
121	0828	0831	0835	0839	0842	0846	0849	0853	0856	0860	0864
122	0864	0867	0871	0874	0878	0881	0885	0888	0892	0896	0899
123	0899	0903	0906	0910	0913	0917	0920	0924	0927	0931	0934
124	0934	0938	0941	0945	0948	0952	0955	0959	0962	0966	0969
125	0969	0973	0976	0980	0983	0986	0990	0993	0997	1000	1004
126	1004	1007	1011	1014	1017	1021	1024	1028	1031	1035	1038
127	1038	1041	1045	1048	1052	1055	1059	1062	1065	1069	1072
128	1072	1075	1079	1082	1086	1089	1092	1096	1099	1103	1106
129	1106	1109	1113	1116	1119	1123	1126	1129	1133	1136	1139
130	1139	1143	1146	1149	1153	1156	1159	1163	1166	1169	1173
131	1173	1176	1179	1183	1186	1189	1193	1196	1199	1202	1206
132	1206	1209	1212	1216	1219	1222	1225	1229	1232	1235	1239
133	1239	1242	1245	1248	1252	1255	1258	1261	1265	1268	1271
134	1271	1274	1278	1281	1284	1287	1290	1294	1297	1300	1303
135	1303	1307	1310	1313	1316	1319	1323	1326	1329	1332	1335
136	1335	1339	1342	1345	1348	1351	1355	1358	1361	1364	1367
137	1367	1370	1374	1377	1380	1383	1386	1389	1392	1396	1399
138	1399	1402	1405	1408	1411	1414	1418	1421	1424	1427	1430
139	1430	1433	1436	1440	1443	1446	1449	1452	1455	1458	1461
140	1461	1464	1467	1471	1474	1477	1480	1483	1486	1489	1492
141	1492	1495	1498	1501	1504	1508	1511	1514	1517	1520	1523
142	1523	1526	1529	1532	1535	1538	1541	1544	1547	1550	1553
143	1553	1556	1559	1562	1565	1569	1572	1575	1578	1581	1584
144	1584	1587	1590	1593	1596	1599	1602	1605	1608	1611	1614
145	1614	1617	1620	1623	1626	1629	1632	1635	1638	1641	1644
146	1644	1647	1649	1652	1655	1658	1661	1664	1667	1670	1673
147	1673	1676	1679	1682	1685	1688	1691	1694	1697	1700	1703
148	1703	1706	1708	1711	1714	1717	1720	1723	1726	1729	1732
149	1732	1735	1738	1741	1744	1746	1749	1752	1755	1758	1761

TABLE 7 (*continued*).

LOGARITHMS.

N.	0	1	2	3	4	5	6	7	8	9	10
150	1761	1764	1767	1770	1772	1775	1778	1781	1784	1787	1790
151	1790	1793	1796	1798	1801	1804	1807	1810	1813	1816	1818
152	1818	1821	1824	1827	1830	1833	1836	1838	1841	1844	1847
153	1847	1850	1853	1855	1858	1861	1864	1867	1870	1872	1875
154	1875	1878	1881	1884	1886	1889	1892	1895	1898	1901	1903
155	1903	1906	1909	1912	1915	1917	1920	1923	1926	1928	1931
156	1931	1934	1937	1940	1942	1945	1948	1951	1953	1956	1959
157	1959	1962	1965	1967	1970	1973	1976	1978	1981	1984	1987
158	1987	1989	1992	1995	1998	2000	2003	2006	2009	2011	2014
159	2014	2017	2019	2022	2025	2028	2030	2033	2036	2038	2041
160	2041	2044	2047	2049	2052	2055	2057	2060	2063	2066	2068
161	2068	2071	2074	2076	2079	2082	2084	2087	2090	2092	2095
162	2095	2098	2101	2103	2106	2109	2111	2114	2117	2119	2122
163	2122	2125	2127	2130	2133	2135	2138	2140	2143	2146	2148
164	2148	2151	2154	2156	2159	2162	2164	2167	2170	2172	2175
165	2175	2177	2180	2183	2185	2188	2191	2193	2196	2198	2201
166	2201	2204	2206	2209	2212	2214	2217	2219	2222	2225	2227
167	2227	2230	2232	2235	2238	2240	2243	2245	2248	2251	2253
168	2253	2256	2258	2261	2263	2266	2269	2271	2274	2276	2279
169	2279	2281	2284	2287	2289	2292	2294	2297	2299	2302	2304
170	2304	2307	2310	2312	2315	2317	2320	2322	2325	2327	2330
171	2330	2333	2335	2338	2340	2343	2345	2348	2350	2353	2355
172	2355	2358	2360	2363	2365	2368	2370	2373	2375	2378	2380
173	2380	2383	2385	2388	2390	2393	2395	2398	2400	2403	2405
174	2405	2408	2410	2413	2415	2418	2420	2423	2425	2428	2430
175	2430	2433	2435	2438	2440	2443	2445	2448	2450	2453	2455
176	2455	2458	2460	2463	2465	2467	2470	2472	2475	2477	2480
177	2480	2482	2485	2487	2490	2492	2494	2497	2499	2502	2504
178	2504	2507	2509	2512	2514	2516	2519	2521	2524	2526	2529
179	2529	2531	2533	2536	2538	2541	2543	2545	2548	2550	2553
180	2553	2555	2558	2560	2562	2565	2567	2570	2572	2574	2577
181	2577	2579	2582	2584	2586	2589	2591	2594	2596	2598	2601
182	2601	2603	2605	2608	2610	2613	2615	2617	2620	2622	2625
183	2625	2627	2629	2632	2634	2636	2639	2641	2643	2646	2648
184	2648	2651	2653	2655	2658	2660	2662	2665	2667	2669	2672
185	2672	2674	2676	2679	2681	2683	2686	2688	2690	2693	2695
186	2695	2697	2700	2702	2704	2707	2709	2711	2714	2716	2718
187	2718	2721	2723	2725	2728	2730	2732	2735	2737	2739	2742
188	2742	2744	2746	2749	2751	2753	2755	2758	2760	2762	2765
189	2765	2767	2769	2772	2774	2776	2778	2781	2783	2785	2788
190	2788	2790	2792	2794	2797	2799	2801	2804	2806	2808	2810
191	2810	2813	2815	2817	2819	2822	2824	2826	2828	2831	2833
192	2833	2835	2838	2840	2842	2844	2847	2849	2851	2853	2856
193	2856	2858	2860	2862	2865	2867	2869	2871	2874	2876	2878
194	2878	2880	2882	2885	2887	2889	2891	2894	2896	2898	2900
195	2900	2903	2905	2907	2909	2911	2914	2916	2918	2920	2923
196	2923	2925	2927	2929	2931	2934	2936	2938	2940	2942	2945
197	2945	2947	2949	2951	2953	2956	2958	2960	2962	2964	2967
198	2967	2969	2971	2973	2975	2978	2980	2982	2984	2986	2989
199	2989	2991	2993	2995	2997	2999	3002	3004	3006	3008	3010

TABLE 8.

LOGARITHMS.

N	0	1	2	3	4	5	6	7	8	9	P. P.				
											1	2	3	4	5
10	0000	0043	0086	0128	0170	0212	0253	0294	0334	0374	4	8	12	17	21
11	0414	0453	0492	0531	0569	0607	0645	0682	0719	0755	4	8	11	15	19
12	0792	0828	0864	0899	0934	0969	1004	1038	1072	1106	3	7	10	14	17
13	1139	1173	1206	1239	1271	1303	1335	1367	1399	1430	3	6	10	13	16
14	1461	1492	1523	1553	1584	1614	1644	1673	1703	1732	3	6	9	12	15
15	1761	1790	1818	1847	1875	1903	1931	1959	1987	2014	3	6	8	11	14
16	2041	2068	2095	2122	2148	2175	2201	2227	2253	2270	3	5	8	11	13
17	2304	2330	2355	2380	2405	2430	2455	2480	2504	2529	2	5	7	10	12
18	2553	2577	2601	2625	2648	2672	2695	2718	2742	2765	2	5	7	9	12
19	2788	2810	2833	2856	2878	2900	2923	2945	2967	2989	2	4	7	9	11
20	3010	3032	3054	3075	3096	3118	3139	3160	3181	3201	2	4	6	8	11
21	3222	3243	3263	3284	3304	3324	3345	3365	3385	3404	2	4	6	8	10
22	3424	3444	3464	3483	3502	3522	3541	3560	3579	3598	2	4	6	8	10
23	3617	3636	3655	3674	3692	3711	3729	3747	3766	3784	2	4	5	7	9
24	3802	3820	3838	3856	3874	3892	3909	3927	3945	3962	2	4	5	7	9
25	3979	3997	4014	4031	4048	4065	4082	4099	4116	4133	2	3	5	7	9
26	4150	4166	4183	4200	4216	4232	4249	4265	4281	4298	2	3	5	7	8
27	4314	4330	4346	4362	4378	4393	4409	4425	4440	4456	2	3	5	6	8
28	4472	4487	4502	4518	4533	4548	4564	4579	4594	4609	2	3	5	6	8
29	4624	4639	4654	4669	4683	4698	4713	4728	4742	4757	1	3	4	6	7
30	4771	4786	4800	4814	4829	4843	4857	4871	4886	4900	1	3	4	6	7
31	4914	4928	4942	4955	4969	4983	4997	5011	5024	5038	1	3	4	6	7
32	5051	5065	5079	5092	5105	5119	5132	5145	5159	5172	1	3	4	5	7
33	5185	5198	5211	5224	5237	5250	5263	5276	5289	5302	1	3	4	5	6
34	5315	5328	5340	5353	5366	5378	5391	5403	5416	5428	1	3	4	5	6
35	5441	5453	5465	5478	5490	5502	5514	5527	5539	5551	1	2	4	5	6
36	5563	5575	5587	5599	5611	5623	5635	5647	5658	5670	1	2	4	5	6
37	5682	5694	5705	5717	5729	5740	5752	5763	5775	5786	1	2	3	5	6
38	5798	5809	5821	5832	5843	5855	5866	5877	5888	5899	1	2	3	5	6
39	5911	5922	5933	5944	5955	5966	5977	5988	5999	6010	1	2	3	4	6
40	6021	6031	6042	6053	6064	6075	6085	6096	6107	6117	1	2	3	4	5
41	6128	6138	6149	6160	6170	6180	6191	6201	6212	6222	1	2	3	4	5
42	6232	6243	6253	6263	6274	6284	6294	6304	6314	6325	1	2	3	4	5
43	6335	6345	6355	6365	6375	6385	6395	6405	6415	6425	1	2	3	4	5
44	6435	6444	6454	6464	6474	6484	6493	6503	6513	6522	1	2	3	4	5
45	6532	6542	6551	6561	6571	6580	6590	6599	6609	6618	1	2	3	4	5
46	6628	6637	6646	6656	6665	6675	6684	6693	6702	6712	1	2	3	4	5
47	6721	6730	6739	6749	6758	6767	6776	6785	6794	6803	1	2	3	4	5
48	6812	6821	6830	6839	6848	6857	6866	6875	6884	6893	1	2	3	4	4
49	6902	6911	6920	6928	6937	6946	6955	6964	6972	6981	1	2	3	4	4
50	6990	6998	7007	7016	7024	7033	7042	7050	7059	7067	1	2	3	3	4
51	7076	7084	7093	7101	7110	7118	7126	7135	7143	7152	1	2	3	3	4
52	7160	7168	7177	7185	7193	7202	7210	7218	7226	7235	1	2	2	3	4
53	7243	7251	7259	7267	7275	7284	7292	7300	7308	7316	1	2	2	3	4
54	7324	7332	7340	7348	7356	7364	7372	7380	7388	7396	1	2	2	3	4

LOGARITHMS.

N.	0	1	2	3	4	5	6	7	8	9	P. P. 1	P. P. 2	P. P. 3	P. P. 4	P. P. 5
55	7404	7412	7419	7427	7435	7443	7451	7459	7466	7474	1	2	2	3	4
56	7482	7490	7497	7505	7513	7520	7528	7535	7543	7551	1	2	2	3	4
57	7559	7566	7574	7582	7589	7597	7604	7612	7619	7627	1	2	2	3	4
58	7634	7642	7649	7657	7664	7672	7679	7686	7694	7701	1	1	2	3	4
59	7709	7716	7723	7731	7738	7745	7752	7760	7767	7774	1	1	2	3	4
60	7782	7789	7796	7803	7810	7818	7825	7832	7839	7846	1	1	2	3	4
61	7853	7860	7868	7875	7882	7889	7896	7903	7910	7917	1	1	2	3	4
62	7924	7931	7938	7945	7952	7959	7966	7973	7980	7987	1	1	2	3	3
63	7993	8000	8007	8014	8021	8028	8035	8041	8048	8055	1	1	2	3	3
64	8062	8069	8075	8082	8089	8096	8102	8109	8116	8122	1	1	2	3	3
65	8129	8136	8142	8149	8156	8162	8169	8176	8182	8189	1	1	2	3	3
66	8195	8202	8209	8215	8222	8228	8235	8241	8248	8254	1	1	2	3	3
67	8261	8267	8274	8280	8287	8293	8299	8306	8312	8319	1	1	2	3	3
68	8325	8331	8338	8344	8351	8357	8363	8370	8376	8382	1	1	2	3	3
69	8388	8395	8401	8407	8414	8420	8426	8432	8439	8445	1	1	2	3	3
70	8451	8457	8463	8470	8476	8482	8488	8494	8500	8506	1	1	2	2	3
71	8513	8519	8525	8531	8537	8543	8549	8555	8561	8567	1	1	2	2	3
72	8573	8579	8585	8591	8597	8603	8609	8615	8621	8627	1	1	2	2	3
73	8633	8639	8645	8651	8657	8663	8669	8675	8681	8686	1	1	2	2	3
74	8692	8698	8704	8710	8716	8722	8727	8733	8739	8745	1	1	2	2	3
75	8751	8756	8762	8768	8774	8779	8785	8791	8797	8802	1	1	2	2	3
76	8808	8814	8820	8825	8831	8837	8842	8848	8854	8859	1	1	2	2	3
77	8865	8871	8876	8882	8887	8893	8899	8904	8910	8915	1	1	2	2	3
78	8921	8927	8932	8938	8943	8949	8954	8960	8965	8971	1	1	2	2	3
79	8976	8982	8987	8993	8998	9004	9009	9015	9020	9025	1	1	2	2	3
80	9031	9036	9042	9047	9053	9058	9063	9069	9074	9079	1	1	2	2	3
81	9085	9090	9096	9101	9106	9112	9117	9122	9128	9133	1	1	2	2	3
82	9138	9143	9149	9154	9159	9165	9170	9175	9180	9186	1	1	2	2	3
83	9191	9196	9201	9206	9212	9217	9222	9227	9232	9238	1	1	2	2	3
84	9243	9248	9253	9258	9263	9269	9274	9279	9284	9289	1	1	2	2	3
85	9294	9299	9304	9309	9315	9320	9325	9330	9335	9340	1	1	2	2	3
86	9345	9350	9355	9360	9365	9370	9375	9380	9385	9390	1	1	2	2	3
87	9395	9400	9405	9410	9415	9420	9425	9430	9435	9440	0	1	1	2	2
88	9445	9450	9455	9460	9465	9469	9474	9479	9484	9489	0	1	1	2	2
89	9494	9499	9504	9509	9513	9518	9523	9528	9533	9538	0	1	1	2	2
90	9542	9547	9552	9557	9562	9566	9571	9576	9581	9586	0	1	1	2	2
91	9590	9595	9600	9605	9609	9614	9619	9624	9628	9633	0	1	1	2	2
92	9638	9643	9647	9652	9657	9661	9666	9671	9675	9680	0	1	1	2	2
93	9685	9689	9694	9699	9703	9708	9713	9717	9722	9727	0	1	1	2	2
94	9731	9736	9741	9745	9750	9754	9759	9763	9768	9773	0	1	1	2	2
95	9777	9782	9786	9791	9795	9800	9805	9809	9814	9818	0	1	1	2	2
96	9823	9827	9832	9836	9841	9845	9850	9854	9859	9863	0	1	1	2	2
97	9868	9872	9877	9881	9886	9890	9894	9899	9903	9908	0	1	1	2	2
98	9912	9917	9921	9926	9930	9934	9939	9943	9948	9952	0	1	1	2	2
99	9956	9961	9965	9969	9974	9978	9983	9987	9991	9996	0	1	1	2	2

TABLE 9.

ANTILOGARITHMS.

	0	1	2	3	4	5	6	7	8	9	P. P.				
											1	2	3	4	5
.00	1000	1002	1005	1007	1009	1012	1014	1016	1019	1021	0	0	1	1	1
.01	1023	1026	1028	1030	1033	1035	1038	1040	1042	1045	0	0	1	1	1
.02	1047	1050	1052	1054	1057	1059	1062	1064	1067	1069	0	0	1	1	1
.03	1072	1074	1076	1079	1081	1084	1086	1089	1091	1094	0	0	1	1	1
.04	1096	1099	1102	1104	1107	1109	1112	1114	1117	1119	0	1	1	1	1
.05	1122	1125	1127	1130	1132	1135	1138	1140	1143	1146	0	1	1	1	1
.06	1148	1151	1153	1156	1159	1161	1164	1167	1169	1172	0	1	1	1	1
.07	1175	1178	1180	1183	1186	1189	1191	1194	1197	1199	0	1	1	1	1
.08	1202	1205	1208	1211	1213	1216	1219	1222	1225	1227	0	1	1	1	1
.09	1230	1233	1236	1239	1242	1245	1247	1250	1253	1256	0	1	1	1	1
.10	1259	1262	1265	1268	1271	1274	1276	1279	1282	1285	0	1	1	1	1
.11	1288	1291	1294	1297	1300	1303	1306	1309	1312	1315	0	1	1	1	2
.12	1318	1321	1324	1327	1330	1334	1337	1340	1343	1346	0	1	1	1	2
.13	1349	1352	1355	1358	1361	1365	1368	1371	1374	1377	0	1	1	1	2
.14	1380	1384	1387	1390	1393	1396	1400	1403	1406	1409	0	1	1	1	2
.15	1413	1416	1419	1422	1426	1429	1432	1435	1439	1442	0	1	1	1	2
.16	1445	1449	1452	1455	1459	1462	1466	1469	1472	1476	0	1	1	1	2
.17	1479	1483	1486	1489	1493	1496	1500	1503	1507	1510	0	1	1	1	2
.18	1514	1517	1521	1524	1528	1531	1535	1538	1542	1545	0	1	1	1	2
.19	1549	1552	1556	1560	1563	1567	1570	1574	1578	1581	0	1	1	1	2
.20	1585	1589	1592	1596	1600	1603	1607	1611	1614	1618	0	1	1	1	2
.21	1622	1626	1629	1633	1637	1641	1644	1648	1652	1656	0	1	1	2	2
.22	1660	1663	1667	1671	1675	1679	1683	1687	1690	1694	0	1	1	2	2
.23	1698	1702	1706	1710	1714	1718	1722	1726	1730	1734	0	1	1	2	2
.24	1738	1742	1746	1750	1754	1758	1762	1766	1770	1774	0	1	1	2	2
.25	1778	1782	1786	1791	1795	1799	1803	1807	1811	1816	0	1	1	2	2
.26	1820	1824	1828	1832	1837	1841	1845	1849	1854	1858	0	1	1	2	2
.27	1862	1866	1871	1875	1879	1884	1888	1892	1897	1901	0	1	1	2	2
.28	1905	1910	1914	1919	1923	1928	1932	1936	1941	1945	0	1	1	2	2
.29	1950	1954	1959	1963	1968	1972	1977	1982	1986	1991	0	1	1	2	2
.30	1995	2000	2004	2009	2014	2018	2023	2028	2032	2037	0	1	1	2	2
.31	2042	2046	2051	2056	2061	2065	2070	2075	2080	2084	0	1	1	2	2
.32	2089	2094	2099	2104	2109	2113	2118	2123	2128	2133	0	1	1	2	2
.33	2138	2143	2148	2153	2158	2163	2168	2173	2178	2183	0	1	1	2	2
.34	2188	2193	2198	2203	2208	2213	2218	2223	2228	2234	1	1	2	2	3
.35	2239	2244	2249	2254	2259	2265	2270	2275	2280	2286	1	1	2	2	3
.36	2291	2296	2301	2307	2312	2317	2323	2328	2333	2339	1	1	2	2	3
.37	2344	2350	2355	2360	2366	2371	2377	2382	2388	2393	1	1	2	2	3
.38	2399	2404	2410	2415	2421	2427	2432	2438	2443	2449	1	1	2	2	3
.39	2455	2460	2466	2472	2477	2483	2489	2495	2500	2506	1	1	2	2	3
.40	2512	2518	2523	2529	2535	2541	2547	2553	2559	2564	1	1	2	2	3
.41	2570	2576	2582	2588	2594	2600	2606	2612	2618	2624	1	1	2	2	3
.42	2630	2636	2642	2649	2655	2661	2667	2673	2679	2685	1	1	2	2	3
.43	2692	2698	2704	2710	2716	2723	2729	2735	2742	2748	1	1	2	3	3
.44	2754	2761	2767	2773	2780	2786	2793	2799	2805	2812	1	1	2	3	3
.45	2818	2825	2831	2838	2844	2851	2858	2864	2871	2877	1	1	2	3	3
.46	2884	2891	2897	2904	2911	2917	2924	2931	2938	2944	1	1	2	3	3
.47	2951	2958	2965	2972	2979	2985	2992	2999	3006	3013	1	1	2	3	3
.48	3020	3027	3034	3041	3048	3055	3062	3069	3076	3083	1	1	2	3	4
.49	3090	3097	3105	3112	3119	3126	3133	3141	3148	3155	1	1	2	3	4

TABLE 9 (*continued*).

ANTILOGARITHMS.

	0	1	2	3	4	5	6	7	8	9	P. P. 1	2	3	4	5
.50	3162	3170	3177	3184	3192	3199	3206	3214	3221	3228	1	1	2	3	4
.51	3236	3243	3251	3258	3266	3273	3281	3289	3296	3304	1	2	2	3	4
.52	3311	3319	3327	3334	3342	3350	3357	3365	3373	3381	1	2	2	3	4
.53	3388	3396	3404	3412	3420	3428	3436	3443	3451	3459	1	2	2	3	4
.54	3467	3475	3483	3491	3499	3508	3516	3524	3532	3540	1	2	2	3	4
.55	3548	3556	3565	3573	3581	3589	3597	3606	3614	3622	1	2	2	3	4
.56	3631	3639	3648	3656	3664	3673	3681	3690	3698	3707	1	2	3	3	4
.57	3715	3724	3733	3741	3750	3758	3767	3776	3784	3793	1	2	3	3	4
.58	3802	3811	3819	3828	3837	3846	3855	3864	3873	3882	1	2	3	4	4
.59	3890	3899	3908	3917	3926	3936	3945	3954	3963	3972	1	2	3	4	5
.60	3981	3990	3999	4009	4018	4027	4036	4046	4055	4064	1	2	3	4	5
.61	4074	4083	4093	4102	4111	4121	4130	4140	4150	4159	1	2	3	4	5
.62	4169	4178	4188	4198	4207	4217	4227	4236	4246	4256	1	2	3	4	5
.63	4266	4276	4285	4295	4305	4315	4325	4335	4345	4355	1	2	3	4	5
.64	4365	4375	4385	4395	4406	4416	4426	4436	4446	4457	1	2	3	4	5
.65	4467	4477	4487	4498	4508	4519	4529	4539	4550	4560	1	2	3	4	5
.66	4571	4581	4592	4603	4613	4624	4634	4645	4656	4667	1	2	3	4	5
.67	4677	4688	4699	4710	4721	4732	4742	4753	4764	4775	1	2	3	4	5
.68	4786	4797	4808	4819	4831	4842	4853	4864	4875	4887	1	2	3	4	6
.69	4898	4909	4920	4932	4943	4955	4966	4977	4989	5000	1	2	3	5	6
.70	5012	5023	5035	5047	5058	5070	5082	5093	5105	5117	1	2	4	5	6
.71	5129	5140	5152	5164	5176	5188	5200	5212	5224	5236	1	2	4	5	6
.72	5248	5260	5272	5284	5297	5309	5321	5333	5346	5358	1	2	4	5	6
.73	5370	5383	5395	5408	5420	5433	5445	5458	5470	5483	1	3	4	5	6
.74	5495	5508	5521	5534	5546	5559	5572	5585	5598	5610	1	3	4	5	6
.75	5623	5636	5649	5662	5675	5689	5702	5715	5728	5741	1	3	4	5	7
.76	5754	5768	5781	5794	5808	5821	5834	5848	5861	5875	1	3	4	5	7
.77	5888	5902	5916	5929	5943	5957	5970	5984	5998	6012	1	3	4	5	7
.78	6026	6039	6053	6067	6081	6095	6109	6124	6138	6152	1	3	4	6	7
.79	6166	6180	6194	6209	6223	6237	6252	6266	6281	6295	1	3	4	6	7
.80	6310	6324	6339	6353	6368	6383	6397	6412	6427	6442	1	3	4	6	7
.81	6457	6471	6486	6501	6516	6531	6546	6561	6577	6592	2	3	5	6	8
.82	6607	6622	6637	6653	6668	6683	6699	6714	6730	6745	2	3	5	6	8
.83	6761	6776	6792	6808	6823	6839	6855	6871	6887	6902	2	3	5	6	8
.84	6918	6934	6950	6966	6982	6998	7015	7031	7047	7063	2	3	5	6	8
.85	7079	7096	7112	7129	7145	7161	7178	7194	7211	7228	2	3	5	7	8
.86	7244	7261	7278	7295	7311	7328	7345	7362	7379	7396	2	3	5	7	8
.87	7413	7430	7447	7464	7482	7499	7516	7534	7551	7568	2	3	5	7	9
.88	7586	7603	7621	7638	7656	7674	7691	7709	7727	7745	2	4	5	7	9
.89	7762	7780	7798	7816	7834	7852	7870	7889	7907	7925	2	4	5	7	9
.90	7943	7962	7980	7998	8017	8035	8054	8072	8091	8110	2	4	6	7	9
.91	8128	8147	8166	8185	8204	8222	8241	8260	8279	8299	2	4	6	8	9
.92	8318	8337	8356	8375	8395	8414	8433	8453	8472	8492	2	4	6	8	10
.93	8511	8531	8551	8570	8590	8610	8630	8650	8670	8690	2	4	6	8	10
.94	8710	8730	8750	8770	8790	8810	8831	8851	8872	8892	2	4	6	8	10
.95	8913	8933	8954	8974	8995	9016	9036	9057	9078	9099	2	4	6	8	10
.96	9120	9141	9162	9183	9204	9226	9247	9268	9290	9311	2	4	6	8	11
.97	9333	9354	9376	9397	9419	9441	9462	9484	9506	9528	2	4	7	9	11
.98	9550	9572	9594	9616	9638	9661	9683	9705	9727	9750	2	4	7	9	11
.99	9772	9795	9817	9840	9863	9886	9908	9931	9954	9977	2	5	7	9	11

Table 10.

ANTILOGARITHMS.

	0	1	2	3	4	5	6	7	8	9	10
.900	7943	7945	7947	7949	7951	7952	7954	7956	7958	7960	7962
.901	7962	7963	7965	7967	7969	7971	7973	7974	7976	7978	7980
.902	7980	7982	7984	7985	7987	7989	7991	7993	7995	7997	7998
.903	7998	8000	8002	8004	8006	8008	8009	8011	8013	8015	8017
.904	8017	8019	8020	8022	8024	8026	8028	8030	8032	8033	8035
.905	8035	8037	8039	8041	8043	8045	8046	8048	8050	8052	8054
.906	8054	8056	8057	8059	8061	8063	8065	8067	8069	8070	8072
.907	8072	8074	8076	8078	8080	8082	8084	8085	8087	8089	8091
.908	8091	8093	8095	8097	8098	8100	8102	8104	8106	8108	8110
.909	8110	8111	8113	8115	8117	8119	8121	8123	8125	8126	8128
.910	8128	8130	8132	8134	8136	8138	8140	8141	8143	8145	8147
.911	8147	8149	8151	8153	8155	8156	8158	8168	8162	8164	8166
.912	8166	8168	8170	8171	8173	8175	8177	8179	8181	8183	8185
.913	8185	8187	8188	8190	8192	8194	8196	8198	8200	8202	8204
.914	8204	8205	8207	8209	8211	8213	8215	8217	8219	8221	8222
.915	8222	8224	8226	8228	8230	8232	8234	8236	8238	8239	8241
.916	8241	8243	8245	8247	8249	8251	8253	8255	8257	8258	8260
.917	8260	8262	8264	8266	8268	8270	8272	8274	8276	8278	8279
.918	8279	8281	8283	8285	8287	8289	8291	8293	8295	8297	8299
.919	8299	8300	8302	8304	8306	8308	8310	8312	8314	8316	8318
.920	8318	8320	8321	8323	8325	8327	8329	8331	8333	8335	8337
.921	8337	8339	8341	8343	8344	8346	8348	8350	8352	8354	8356
.922	8356	8358	8360	8362	8364	8366	8368	8370	8371	8373	8375
.923	8375	8377	8379	8381	8383	8385	8387	8389	8391	8393	8395
.924	8395	8397	8398	8400	8402	8404	8406	8408	8410	8412	8414
.925	8414	8416	8418	8420	8422	8424	8426	8428	8429	8431	8433
.926	8433	8435	8437	8439	8441	8443	8445	8447	8449	8451	8453
.927	8453	8455	8457	8459	8461	8463	8464	8466	8468	8470	8472
.928	8472	8474	8476	8478	8480	8482	8484	8486	8488	8490	8492
.929	8492	8494	8496	8498	8500	8502	8504	8506	8507	8509	8511
.930	8511	8513	8515	8517	8519	8521	8523	8525	8527	8529	8531
.931	8531	8533	8535	8537	8539	8541	8543	8545	8547	8549	8551
.932	8551	8553	8555	8557	8559	8561	8562	8564	8566	8568	8570
.933	8570	8572	8574	8576	8578	8580	8582	8584	8586	8588	8590
.934	8590	8592	8594	8596	8598	8600	8602	8604	8606	8608	8610
.935	8610	8612	8614	8616	8618	8620	8622	8624	8626	8628	8630
.936	8630	8632	8634	8636	8638	8640	8642	8644	8646	8648	8650
.937	8650	8652	8654	8656	8658	8660	8662	8664	8666	8668	8670
.938	8670	8672	8674	8676	8678	8680	8682	8684	8686	8688	8690
.939	8690	8692	8694	8696	8698	8700	8702	8704	8706	8708	8710
.940	8710	8712	8714	8716	8718	8720	8722	8724	8726	8728	8730
.941	8730	8732	8734	8736	8738	8740	8742	8744	8746	8748	8750
.942	8750	8752	8754	8756	8758	8760	8762	8764	8766	8768	8770
.943	8770	8772	8774	8776	8778	8780	8782	8784	8786	8788	8790
.944	8790	8792	8794	8796	8798	8800	8802	8804	8806	8808	8810
.945	8810	8813	8815	8817	8819	8821	8823	8825	8827	8829	8831
.946	8831	8833	8835	8837	8839	8841	8843	8845	8847	8849	8851
.947	8851	8853	8855	8857	8859	8861	8863	8865	8867	8870	8872
.948	8872	8874	8876	8878	8880	8882	8884	8886	8888	8890	8892
.949	8892	8894	8896	8898	8900	8902	8904	8906	8908	8910	8913

TABLE 10 (*continued*).

ANTILOGARITHMS.

	0	1	2	3	4	5	6	7	8	9	10
.950	8913	8915	8917	8919	8921	8923	8925	8927	8929	8931	8933
.951	8933	8935	8937	8939	8941	8943	8945	8947	8950	8952	8954
.952	8954	8956	8958	8960	8962	8964	8966	8968	8970	8972	8974
.953	8974	8976	8978	8980	8983	8985	8987	8989	8991	8993	8995
.954	8995	8997	8999	9001	9003	9005	9007	9009	9012	9014	9016
.955	9016	9018	9020	9022	9024	9026	9028	9030	9032	9034	9036
.956	9036	9039	9041	9043	9045	9047	9049	9051	9053	9055	9057
.957	9057	9059	9061	9064	9066	9068	9070	9072	9074	9076	9078
.958	9078	9080	9082	9084	9087	9089	9091	9093	9095	9097	9099
.959	9099	9101	9103	9105	9108	9110	9112	9114	9116	9118	9120
.960	9120	9122	9124	9126	9129	9131	9133	9135	9137	9139	9141
.961	9141	9143	9145	9147	9150	9152	9154	9156	9158	9160	9162
.962	9162	9164	9166	9169	9171	9173	9175	9177	9179	9181	9183
.963	9183	9185	9188	9190	9192	9194	9196	9198	9200	9202	9204
.964	9204	9207	9209	9211	9213	9215	9217	9219	9221	9224	9226
.965	9226	9228	9230	9232	9234	9236	9238	9241	9243	9245	9247
.966	9247	9249	9251	9253	9256	9258	9260	9262	9264	9266	9268
.967	9268	9270	9273	9275	9277	9279	9281	9283	9285	9288	9290
.968	9290	9292	9294	9296	9298	9300	9303	9305	9307	9309	9311
.969	9311	9313	9315	9318	9320	9322	9324	9326	9328	9330	9333
.970	9333	9335	9337	9339	9341	9343	9345	9348	9350	9352	9354
.971	9354	9356	9358	9361	9363	9365	9367	9369	9371	9373	9376
.972	9376	9378	9380	9382	9384	9386	9389	9391	9393	9395	9397
.973	9397	9399	9402	9404	9406	9408	9410	9412	9415	9417	9419
.974	9419	9421	9423	9425	9428	9430	9432	9434	9436	9438	9441
.975	9441	9443	9445	9447	9449	9451	9454	9456	9458	9460	9462
.976	9462	9465	9467	9469	9471	9473	9475	9478	9480	9482	9484
.977	9484	9486	9489	9491	9493	9495	9497	9499	9502	9504	9506
.978	9506	9508	9510	9513	9515	9517	9519	9521	9524	9526	9528
.979	9528	9530	9532	9535	9537	9539	9541	9543	9546	9548	9550
.980	9550	9552	9554	9557	9559	9561	9563	9565	9568	9570	9572
.981	9572	9574	9576	9579	9581	9583	9585	9587	9590	9592	9594
.982	9594	9596	9598	9601	9603	9605	9607	9609	9612	9614	9616
.983	9616	9618	9621	9623	9625	9627	9629	9632	9634	9636	9638
.984	9638	9641	9643	9645	9647	9649	9652	9654	9656	9658	9661
.985	9661	9663	9665	9667	9669	9672	9674	9676	9678	9681	9683
.986	9683	9685	9687	9689	9692	9694	9696	9698	9701	9703	9705
.987	9705	9707	9710	9712	9714	9716	9719	9721	9723	9725	9727
.988	9727	9730	9732	9734	9736	9739	9741	9743	9745	9748	9750
.989	9750	9752	9754	9757	9759	9761	9763	9766	9768	9770	9772
.990	9772	9775	9777	9779	9781	9784	9786	9788	9790	9793	9795
.991	9795	9797	9799	9802	9804	9806	9808	9811	9813	9815	9817
.992	9817	9820	9822	9824	9827	9829	9831	9833	9836	9838	9840
.993	9840	9842	9845	9847	9849	9851	9854	9856	9858	9861	9863
.994	9863	9865	9867	9870	9872	9874	9876	9879	9881	9883	9886
.995	9886	9888	9890	9892	9895	9897	9899	9901	9904	9906	9908
.996	9908	9911	9913	9915	9917	9920	9922	9924	9927	9929	9931
.997	9931	9933	9936	9938	9940	9943	9945	9947	9949	9952	9954
.998	9954	9956	9959	9961	9963	9966	9968	9970	9972	9975	9977
.999	9977	9979	9982	9984	9986	9988	9991	9993	9995	9998	0000

Table 11.

CIRCULAR (TRIGONOMETRIC) FUNCTIONS.

(Taken from B. O. Peirce's "Short Table of Integrals," Ginn & Co.)

RADIANS.	DEGREES.	SINES.		COSINES.		TANGENTS.		COTANGENTS.			
		Nat.	Log.	Nat.	Log.	Nat.	Log.	Nat.	Log.		
0.0000	0°00′	.0000	∞	1.0000	0.0000	.0000	∞	∞	∞	90°00′	1.5708
0.0029	10	.0029	7.4637	1.0000	.0000	.0029	7.4637	343.77	2.5363	50	1.5679
0.0058	20	.0058	.7648	1.0000	.0000	.0058	.7648	171.89	.2352	40	1.5650
0.0087	30	.0087	.9408	1.0000	.0000	.0087	.9409	114.59	.0591	30	1.5621
0.0116	40	.0116	8.0658	.9999	.0000	.0116	8.0658	85.940	1.9342	20	1.5592
0.0145	50	.0145	.1627	.9999	.0000	.0145	.1627	68.750	.8373	10	1.5563
0.0175	1°00′	.0175	8.2419	.9998	9.9999	.0175	8.2419	57.290	1.7581	89°00′	1.5533
0.0204	10	.0204	.3088	.9998	.9999	.0204	.3089	49.104	.6911	50	1.5504
0.0233	20	.0233	.3668	.9997	.9999	.0233	.3669	42.964	.6331	40	1.5475
0.0262	30	.0262	.4179	.9997	.9999	.0262	.4181	38.188	.5819	30	1.5446
0.0291	40	.0291	.4637	.9996	.9998	.0291	.4638	34.368	.5362	20	1.5417
0.0320	50	.0320	.5050	.9995	.9998	.0320	.5053	31.242	.4947	10	1.5388
0.0349	2°00′	.0349	8.5428	.9994	9.9997	.0349	8.5431	28.636	1.4569	88°00′	1.5359
0.0378	10	.0378	.5776	.9993	.9997	.0378	.5779	26.432	.4221	50	1.5330
0.0407	20	.0407	.6097	.9992	.9996	.0407	.6101	24.542	.3899	40	1.5301
0.0436	30	.0436	.6397	.9990	.9996	.0437	.6401	22.904	.3599	30	1.5272
0.0465	40	.0465	.6677	.9989	.9995	.0466	.6682	21.470	.3318	20	1.5243
0.0495	50	.0494	.6940	.9988	.9995	.0495	.6945	20.206	.3055	10	1.5213
0.0524	3°00′	.0523	8.7188	.9986	9.9994	.0524	8.7194	19.081	1.2806	87°00′	1.5184
0.0553	10	.0552	.7423	.9985	.9993	.0553	.7429	18.075	.2571	50	1.5155
0.0582	20	.0581	.7645	.9983	.9993	.0582	.7652	17.169	.2348	40	1.5126
0.0611	30	.0610	.7857	.9981	.9992	.0612	.7865	16.350	.2135	30	1.5097
0.0640	40	.0640	.8059	.9980	.9991	.0641	.8067	15.605	.1933	20	1.5068
0.0669	50	.0669	.8251	.9978	.9990	.0670	.8261	14.924	.1739	10	1.5039
0.0698	4°00′	.0698	8.8436	.9976	9.9989	.0699	8.8446	14.301	1.1554	86°00′	1.5010
0.0727	10	.0727	.8613	.9974	.9989	.0729	.8624	13.727	.1376	50	1.4981
0.0756	20	.0756	.8783	.9971	.9988	.0758	.8795	13.197	.1205	40	1.4952
0.0785	30	.0785	.8946	.9969	.9987	.0787	.8960	12.706	.1040	30	1.4923
0.0814	40	.0814	.9104	.9967	.9986	.0816	.9118	12.251	.0882	20	1.4893
0.0844	50	.0843	.9256	.9964	.9985	.0846	.9272	11.826	.0728	10	1.4864
0.0873	5°00′	.0872	8.9403	.9962	9.9983	.0875	8.9420	11.430	1.0580	85°00′	1.4835
0.0902	10	.0901	.9545	.9959	.9982	.0904	.9563	11.059	.0437	50	1.4806
0.0931	20	.0929	.9682	.9957	.9981	.0934	.9701	10.712	.0299	40	1.4777
0.0960	30	.0958	.9816	.9954	.9980	.0963	.9836	10.385	.0164	30	1.4748
0.0989	40	.0987	.9945	.9951	.9979	.0992	.9966	10.078	.0034	20	1.4719
0.1018	50	.1016	9.0070	.9948	.9977	.1022	9.0093	9.7882	0.9907	10	1.4690
0.1047	6°00	.1045	9.0192	.9945	9.9976	.1051	9.0216	9.5144	0.9784	84°00′	1.4661
0.1076	10	.1074	.0311	.9942	.9975	.1080	.0336	9.2553	.9664	50	1.4632
0.1105	20	.1103	.0426	.9939	.9973	.1110	.0453	9.0098	.9547	40	1.4603
0.1134	30	.1132	.0539	.9936	.9972	.1139	.0567	8.7769	.9433	30	1.4574
0.1164	40	.1161	.0648	.9932	.9971	.1169	.0678	8.5555	.9322	20	1.4544
0.1193	50	.1190	.0755	.9929	.9969	.1198	.0786	8.3450	.9214	10	1.4515
0.1222	7°00′	.1219	9.0859	.9925	9.9968	.1228	9.0891	8.1443	0.9109	83°00′	1.4486
0.1251	10	.1248	.0961	.9922	.9966	.1257	.0995	7.9530	.9005	50	1.4457
0.1280	20	.1276	.1060	.9918	.9964	.1287	.1096	7.7704	.8904	40	1.4428
0.1309	30	.1305	.1157	.9914	.9963	.1317	.1194	7.5958	.8806	30	1.4399
0.1338	40	.1334	.1252	.9911	.9961	.1346	.1291	7.4287	.8709	20	1.4370
0.1367	50	.1363	.1345	.9907	.9959	.1376	.1385	7.2687	.8615	10	1.4341
0.1396	8°00′	.1392	9.1436	.9903	9.9958	.1405	9.1478	7.1154	0.8522	82°00′	1.4312
0.1425	10	.1421	.1525	.9899	.9956	.1435	.1569	6.9682	.8431	50	1.4283
0.1454	20	.1449	.1612	.9894	.9954	.1465	.1658	6.8269	.8342	40	1.4254
0.1484	30	.1478	.1697	.9890	.9952	.1495	.1745	6.6912	.8255	30	1.4224
0.1513	40	.1507	.1781	.9886	.9950	.1524	.1831	6.5606	.8169	20	1.4195
0.1542	50	.1536	.1863	.9881	.9948	.1554	.1915	6.4348	.8085	10	1.4166
0.1571	9°00′	.1564	9.1943	.9877	9.9946	.1584	9.1997	6.3138	0.8003	81°00′	1.4137
		Nat.	Log.	Nat.	Log.	Nat.	Log.	Nat.	Log.	DEGREES.	RADIANS.
		COSINES.		SINES.		COTANGENTS.		TANGENTS.			

TABLE 11 (*continued*).

CIRCULAR (TRIGONOMETRIC) FUNCTIONS.

RADIANS.	DEGREES.	SINES.		COSINES.		TANGENTS.		COTANGENTS.			
		Nat.	Log.	Nat.	Log.	Nat.	Log.	Nat.	Log.		
0.1571	9°00′	.1564	9.1943	.9877	9.9946	.1584	9.1997	6.3138	0.8003	81°00′	1.4137
0.1600	10	.1593	.2022	.9872	.9944	.1614	.2078	6.1970	.7922	50	1.4108
0.1629	20	.1622	.2100	.9868	.9942	.1644	.2158	6.0844	.7842	40	1.4079
0.1658	30	.1650	.2176	.9863	.9940	.1673	.2236	5.9758	.7764	30	1.4050
0.1687	40	.1679	.2251	.9858	.9938	.1703	.2313	5.8708	.7687	20	1.4021
0.1716	50	.1708	.2324	.9853	.9936	.1733	.2389	5.7694	.7611	10	1.3992
0.1745	10°00′	.1736	9.2397	.9848	9.9934	.1763	9.2463	5.6713	0.7537	80°00′	1.3963
0.1774	10	.1765	.2468	.9843	.9931	.1793	.2536	5.5764	.7464	50	1.3934
0.1804	20	.1794	.2538	.9838	.9929	.1823	.2609	5.4845	.7391	40	1.3904
0.1833	30	.1822	.2606	.9833	.9927	.1853	.2680	5.3955	.7320	30	1.3875
0.1862	40	.1851	.2674	.9827	.9924	.1883	.2750	5.3093	.7250	20	1.3846
0.1891	50	.1880	.2740	.9822	.9922	.1914	.2819	5.2257	.7181	10	1.3817
0.1920	11°00′	.1908	9.2806	.9816	9.9919	.1944	9.2887	5.1446	0.7113	79°00′	1.3788
0.1949	10	.1937	.2870	.9811	.9917	.1974	.2953	5.0658	.7047	50	1.3759
0.1978	20	.1965	.2934	.9805	.9914	.2004	.3020	4.9894	.6980	40	1.3730
0.2007	30	.1994	.2997	.9799	.9912	.2035	.3085	4.9152	.6915	30	1.3701
0.2036	40	.2022	.3058	.9793	.9909	.2065	.3149	4.8430	.6851	20	1.3672
0.2065	50	.2051	.3119	.9787	.9907	.2095	.3212	4.7729	.6788	10	1.3643
0.2094	12°00′	.2079	9.3179	.9781	9.9904	.2126	9.3275	4.7046	0.6725	78°00′	1.3614
0.2123	10	.2108	.3238	.9775	.9901	.2156	.3336	4.6382	.6664	50	1.3584
0.2153	20	.2136	.3296	.9769	.9899	.2186	.3397	4.5736	.6603	40	1.3555
0.2182	30	.2164	.3353	.9763	.9896	.2217	.3458	4.5107	.6542	30	1.3526
0.2211	40	.2193	.3410	.9757	.9893	.2247	.3517	4.4494	.6483	20	1.3497
0.2240	50	.2221	.3466	.9750	.9890	.2278	.3576	4.3897	.6424	10	1.3468
0.2269	13°00′	.2250	9.3521	.9744	9.9887	.2309	9.3634	4.3315	0.6366	77°00′	1.3439
0.2298	10	.2278	.3575	.9737	.9884	.2339	.3691	4.2747	.6309	50	1.3410
0.2327	20	.2306	.3629	.9730	.9881	.2370	.3748	4.2193	.6252	40	1.3381
0.2356	30	.2334	.3682	.9724	.9878	.2401	.3804	4.1653	.6196	30	1.3352
0.2385	40	.2363	.3734	.9717	.9875	.2432	.3859	4.1126	.6141	20	1.3323
0.2414	50	.2391	.3786	.9710	.9872	.2462	.3914	4.0611	.6086	10	1.3294
0.2443	14°00′	.2419	9.3837	.9703	9.9869	.2493	9.3968	4.0108	0.6032	76°00′	1.3265
0.2473	10	.2447	.3887	.9696	.9866	.2524	.4021	3.9617	.5979	50	1.3235
0.2502	20	.2476	.3937	.9689	.9863	.2555	.4074	3.9136	.5926	40	1.3206
0.2531	30	.2504	.3986	.9681	.9859	.2586	.4127	3.8667	.5873	30	1.3177
0.2560	40	.2532	.4035	.9674	.9856	.2617	.4178	3.8208	.5822	20	1.3148
0.2589	50	.2560	.4083	.9667	.9853	.2648	.4230	3.7760	.5770	10	1.3119
0.2618	15°00′	.2588	9.4130	.9659	9.9849	.2679	9.4281	3.7321	0.5719	75°00′	1.3090
0.2647	10	.2616	.4177	.9652	.9846	.2711	.4331	3.6891	.5669	50	1.3061
0.2676	20	.2644	.4223	.9644	.9843	.2742	.4381	3.6470	.5619	40	1.3032
0.2705	30	.2672	.4269	.9636	.9839	.2773	.4430	3.6059	.5570	30	1.3003
0.2734	40	.2700	.4314	.9628	.9836	.2805	.4479	3.5656	.5521	20	1.2974
0.2763	50	.2728	.4359	.9621	.9832	.2836	.4527	3.5261	.5473	10	1.2945
0.2793	16°00′	.2756	9.4403	.9613	9.9828	.2867	9.4575	3.4874	0.5425	74°00′	1.2915
0.2822	10	.2784	.4447	.9605	.9825	.2899	.4622	3.4495	.5378	50	1.2886
0.2851	20	.2812	.4491	.9596	.9821	.2931	.4669	3.4124	.5331	40	1.2857
0.2880	30	.2840	.4533	.9588	.9817	.2962	.4716	3.3759	.5284	30	1.2828
0.2909	40	.2868	.4576	.9580	.9814	.2994	.4762	3.3402	.5238	20	1.2799
0.2938	50	.2896	.4618	.9572	.9810	.3026	.4808	3.3052	.5192	10	1.2770
0.2967	17°00′	.2924	9.4659	.9563	9.9806	.3057	9.4853	3.2709	0.5147	73°00′	1.2741
0.2996	10	.2952	.4700	.9555	.9802	.3089	.4898	3.2371	.5102	50	1.2712
0.3025	20	.2979	.4741	.9546	.9798	.3121	.4943	3.2041	.5057	40	1.2683
0.3054	30	.3007	.4781	.9537	.9794	.3153	.4987	3.1716	.5013	30	1.2654
0.3083	40	.3035	.4821	.9528	.9790	.3185	.5031	3.1397	.4969	20	1.2625
0.3113	50	.3062	.4861	.9520	.9786	.3217	.5075	3.1084	.4925	10	1.2595
0.3142	18°00′	.3090	9.4900	.9511	9.9782	.3249	9.5118	3.0777	0.4882	72°00′	1.2566
		Nat.	Log.	Nat.	Log.	Nat.	Log.	Nat.	Log.	DEGREES.	RADIANS.
		COSINES		SINES.		COTANGENTS.		TANGENTS			

CIRCULAR (TRIGONOMETRIC) FUNCTIONS.

RADIANS.	DEGREES.	SINES.		COSINES.		TANGENTS.		COTANGENTS.			
		Nat.	Log.	Nat.	Log.	Nat.	Log.	Nat.	Log.		
0.3142	18°00′	.3090	9.4900	.9511	9.9782	.3249	9.5118	3.0777	0.4882	72°00′	1.2566
0.3171	10	.3118	.4939	.9502	.9778	.3281	.5161	3.0475	.4839	50	1.2537
0.3200	20	.3145	.4977	.9492	.9774	.3314	.5203	3.0178	.4797	40	1.2508
0.3229	30	.3173	.5015	.9483	.9770	.3346	.5245	2.9887	.4755	30	1.2479
0.3258	40	.3201	.5052	.9474	.9765	.3378	.5287	2.9600	.4713	20	1.2450
0.3287	50	.3228	.5090	.9465	.9761	.3411	.5329	2.9319	.4671	10	1.2421
0.3316	19°00′	.3256	9.5126	.9455	9.9757	.3443	9.5370	2.9042	0.4630	71°00′	1.2392
0.3345	10	.3283	.5163	.9446	.9752	.3476	.5411	2.8770	.4589	50	1.2363
0.3374	20	.3311	.5199	.9436	.9748	.3508	.5451	2.8502	.4549	40	1.2334
0.3403	30	.3338	.5235	.9426	.9743	.3541	.5491	2.8239	.4509	30	1.2305
0.3432	40	.3365	.5270	.9417	.9739	.3574	.5531	2.7980	.4469	20	1.2275
0.3462	50	.3393	.5306	.9407	.9734	.3607	.5571	2.7725	.4429	10	1.2246
0.3491	20°00′	.3420	9.5341	.9397	9.9730	.3640	9.5611	2.7475	0.4389	70°00′	1.2217
0.3520	10	.3448	.5375	.9387	.9725	.3673	.5650	2.7228	.4350	50	1.2188
0.3549	20	.3475	.5409	.9377	.9721	.3706	.5689	2.6985	.4311	40	1.2159
0.3578	30	.3502	.5443	.9367	.9716	.3739	.5727	2.6746	.4273	30	1.2130
0.3607	40	.3529	.5477	.9356	.9711	.3772	.5766	2.6511	.4234	20	1.2101
0.3636	50	.3557	.5510	.9346	.9706	.3805	.5804	2.6279	.4196	10	1.2072
0.3665	21°00′	.3584	9.5543	.9336	9.9702	.3839	9.5842	2.6051	0.4158	69°00′	1.2043
0.3694	10	.3611	.5576	.9325	.9697	.3872	.5879	2.5826	.4121	50	1.2014
0.3723	20	.3638	.5609	.9315	.9692	.3906	.5917	2.5605	.4083	40	1.1985
0.3752	30	.3665	.5641	.9304	.9687	.3939	.5954	2.5386	.4046	30	1.1956
0.3782	40	.3692	.5673	.9293	.9682	.3973	.5991	2.5172	.4009	20	1.1926
0.3811	50	.3719	.5704	.9283	.9677	.4006	.6028	2.4960	.3972	10	1.1897
0.3840	22°00′	.3746	9.5736	.9272	9.9672	.4040	9.6064	2.4751	0.3936	68°00′	1.1868
0.3869	10	.3773	.5767	.9261	.9667	.4074	.6100	2.4545	.3900	50	1.1839
0.3898	20	.3800	.5798	.9250	.9661	.4108	.6136	2.4342	.3864	40	1.1810
0.3927	30	.3827	.5828	.9239	.9656	.4142	.6172	2.4142	.3828	30	1.1781
0.3956	40	.3854	.5859	.9228	.9651	.4176	.6208	2.3945	.3792	20	1.1752
0.3985	50	.3881	.5889	.9216	.9646	.4210	.6243	2.3750	.3757	10	1.1723
0.4014	23°00′	.3907	9.5919	.9205	9.9640	.4245	9.6279	2.3559	0.3721	67°00′	1.1694
0.4043	10	.3934	.5948	.9194	.9635	.4279	.6314	2.3369	.3686	50	1.1665
0.4072	20	.3961	.5978	.9182	.9629	.4314	.6348	2.3183	.3652	40	1.1636
0.4102	30	.3987	.6007	.9171	.9624	.4348	.6383	2.2998	.3617	30	1.1606
0.4131	40	.4014	.6036	.9159	.9618	.4383	.6417	2.2817	.3583	20	1.1577
0.4160	50	.4041	.6065	.9147	.9613	.4417	.6452	2.2637	.3548	10	1.1548
0.4189	24°00′	.4067	9.6093	.9135	9.9607	.4452	9.6486	2.2460	0.3514	66°00′	1.1519
0.4218	10	.4094	.6121	.9124	.9602	.4487	.6520	2.2286	.3480	50	1.1490
0.4247	20	.4120	.6149	.9112	.9596	.4522	.6553	2.2113	.3447	40	1.1461
0.4276	30	.4147	.6177	.9100	.9590	.4557	.6587	2.1943	.3413	30	1.1432
0.4305	40	.4173	.6205	.9088	.9584	.4592	.6620	2.1775	.3380	20	1.1403
0.4334	50	.4200	.6232	.9075	.9579	.4628	.6654	2.1609	.3346	10	1.1374
0.4363	25°00′	.4226	9.6259	.9063	9.9573	.4663	9.6687	2.1445	0.3313	65°00′	1.1345
0.4392	10	.4253	.6286	.9051	.9567	.4699	.6720	2.1283	.3280	50	1.1316
0.4422	20	.4279	.6313	.9038	.9561	.4734	.6752	2.1123	.3248	40	1.1286
0.4451	30	.4305	.6340	.9026	.9555	.4770	.6785	2.0965	.3215	30	1.1257
0.4480	40	.4331	.6366	.9013	.9549	.4806	.6817	2.0809	.3183	20	1.1228
0.4509	50	.4358	.6392	.9001	.9543	.4841	.6850	2.0655	.3150	10	1.1199
0.4538	26°00′	.4384	9.6418	.8988	9.9537	.4877	9.6882	2.0503	0.3118	64°00′	1.1170
0.4567	10	.4410	.6444	.8975	.9530	.4913	.6914	2.0353	.3086	50	1.1141
0.4596	20	.4436	.6470	.8962	.9524	.4950	.6946	2.0204	.3054	40	1.1112
0.4625	30	.4462	.6495	.8949	.9518	.4986	.6977	2.0057	.3023	30	1.1083
0.4654	40	.4488	.6521	.8936	.9512	.5022	.7009	1.9912	.2991	20	1.1054
0.4683	50	.4514	.6546	.8923	.9505	.5059	.7040	1.9768	.2960	10	1.1025
0.4712	27°00′	.4540	9.6570	.8910	9.9499	.5095	9.7072	1.9626	0.2928	63°00′	1.0996
		Nat.	Log.	Nat.	Log.	Nat.	Log.	Nat.	Log.	DEGREES.	RADIANS.
		COSINES.		SINES.		COTANGENTS.		TANGENTS.			

CIRCULAR (TRIGONOMETRIC) FUNCTIONS.

RADIANS.	DEGREES.	SINES.		COSINES.		TANGENTS.		COTANGENTS.			
		Nat.	Log.	Nat.	Log.	Nat.	Log.	Nat.	Log.		
0.4712	27°00′	.4540	9.6570	.8910	9.9499	.5095	9.7072	1.9626	0.2928	63°00′	1.0996
0.4741	10	.4566	.6595	.8897	.9492	.5132	.7103	1.9486	.2897	50	1.0966
0.4771	20	.4592	.6620	.8884	.9486	.5169	.7134	1.9347	.2866	40	1.0937
0.4800	30	.4617	.6644	.8870	.9479	.5206	.7165	1.9210	.2835	30	1.0908
0.4829	40	.4643	.6668	.8857	.9473	.5243	.7196	1.9074	.2804	20	1.0879
0.4858	50	.4669	.6692	.8843	.9466	.5280	.7226	1.8940	.2774	10	1.0850
0.4887	28°00′	.4695	9.6716	.8829	9.9459	.5317	9.7257	1.8807	0.2743	62°00′	1.0821
0.4916	10	.4720	.6740	.8816	.9453	.5354	.7287	1.8676	.2713	50	1.0792
0.4945	20	.4746	.6763	.8802	.9446	.5392	.7317	1.8546	.2683	40	1.0763
0.4974	30	.4772	.6787	.8788	.9439	.5430	.7348	1.8418	.2652	30	1.0734
0.5003	40	.4797	.6810	.8774	.9432	.5467	.7378	1.8291	.2622	20	1.0705
0.5032	50	.4823	.6833	.8760	.9425	.5505	.7408	1.8165	.2592	10	1.0676
0.5061	29°00′	.4848	9.6856	.8746	9.9418	.5543	9.7438	1.8040	0.2562	61°00′	1.0647
0.5091	10	.4874	.6878	.8732	.9411	.5581	.7467	1.7917	.2533	50	1.0617
0.5120	20	.4899	.6901	.8718	.9404	.5619	.7497	1.7796	.2503	40	1.0588
0.5149	30	.4924	.6923	.8704	.9397	.5658	.7526	1.7675	.2474	30	1.0559
0.5178	40	.4950	.6946	.8689	.9390	.5696	.7556	1.7556	.2444	20	1.0530
0.5207	50	.4975	.6968	.8675	.9383	.5735	.7585	1.7437	.2415	10	1.0501
0.5236	30°00′	.5000	9.6990	.8660	9.9375	.5774	9.7614	1.7321	0.2386	60°00′	1.0472
0.5265	10	.5025	.7012	.8646	.9368	.5812	.7644	1.7205	.2356	50	1.0443
0.5294	20	.5050	.7033	.8631	.9361	.5851	.7673	1.7090	.2327	40	1.0414
0.5323	30	.5075	.7055	.8616	.9353	.5890	.7701	1.6977	.2299	30	1.0385
0.5352	40	.5100	.7076	.8601	.9346	.5930	.7730	1.6864	.2270	20	1.0356
0.5381	50	.5125	.7097	.8587	.9338	.5969	.7759	1.6753	.2241	10	1.0327
0.5411	31°00′	.5150	9.7118	.8572	9.9331	.6009	9.7788	1.6643	0.2212	59°00′	1.0297
0.5440	10	.5175	.7139	.8557	.9323	.6048	.7816	1.6534	.2184	50	1.0268
0.5469	20	.5200	.7160	.8542	.9315	.6088	.7845	1.6426	.2155	40	1.0239
0.5498	30	.5225	.7181	.8526	.9308	.6128	.7873	1.6319	.2127	30	1.0210
0.5527	40	.5250	.7201	.8511	.9300	.6168	.7902	1.6212	.2098	20	1.0181
0.5556	50	.5275	.7222	.8496	.9292	.6208	.7930	1.6107	.2070	10	1.0152
0.5585	32°00′	.5299	9.7242	.8480	9.9284	.6249	9.7958	1.6003	0.2042	58°00′	1.0123
0.5614	10	.5324	.7262	.8465	.9276	.6289	.7986	1.5900	.2014	50	1.0094
0.5643	20	.5348	.7282	.8450	.9268	.6330	.8014	1.5798	.1986	40	1.0065
0.5672	30	.5373	.7302	.8434	.9260	.6371	.8042	1.5697	.1958	30	1.0036
0.5701	40	.5398	.7322	.8418	.9252	.6412	.8070	1.5597	.1930	20	1.0007
0.5730	50	.5422	.7342	.8403	.9244	.6453	.8097	1.5497	.1903	10	0.9977
0.5760	33°00′	.5446	9.7361	.8387	9.9236	.6494	9.8125	1.5399	0.1875	57°00′	0.9948
0.5789	10	.5471	.7380	.8371	.9228	.6536	.8153	1.5301	.1847	50	0.9919
0.5818	20	.5495	.7400	.8355	.9219	.6577	.8180	1.5204	.1820	40	0.9890
0.5847	30	.5519	.7419	.8339	.9211	.6619	.8208	1.5108	.1792	30	0.9861
0.5876	40	.5544	.7438	.8323	.9203	.6661	.8235	1.5013	.1765	20	0.9832
0.5905	50	.5568	.7457	.8307	.9194	.6703	.8263	1.4919	.1737	10	0.9803
0.5934	34°00′	.5592	9.7476	.8290	9.9186	.6745	9.8290	1.4826	0.1710	56°00′	0.9774
0.5963	10	.5616	.7494	.8274	.9177	.6787	.8317	1.4733	.1683	50	0.9745
0.5992	20	.5640	.7513	.8258	.9169	.6830	.8344	1.4641	.1656	40	0.9716
0.6021	30	.5664	.7531	.8241	.9160	.6873	.8371	1.4550	.1629	30	0.9687
0.6050	40	.5688	.7550	.8225	.9151	.6916	.8398	1.4460	.1602	20	0.9657
0.6080	50	.5712	.7568	.8208	.9142	.6959	.8425	1.4370	.1575	10	0.9628
0.6109	35°00′	.5736	9.7586	.8192	9.9134	.7002	9.8452	1.4281	0.1548	55°00′	0.9599
0.6138	10	.5760	.7604	.8175	.9125	.7046	.8479	1.4193	.1521	50	0.9570
0.6167	20	.5783	.7622	.8158	.9116	.7089	.8506	1.4106	.1494	40	0.9541
0.6196	30	.5807	.7640	.8141	.9107	.7133	.8533	1.4019	.1467	30	0.9512
0.6225	40	.5831	.7657	.8124	.9098	.7177	.8559	1.3934	.1441	20	0.9483
0.6254	50	.5854	.7675	.8107	.9089	.7221	.8586	1.3848	.1414	10	0.9454
0.6283	36°00′	.5878	9.7692	.8090	9.9080	.7265	9.8613	1.3764	0.1387	54°00′	0.9425
		Nat.	Log.	Nat.	Log.	Nat.	Log.	Nat.	Log.	DEGREES.	RADIANS.
		COSINES.		SINES.		COTANGENTS.		TANGENTS.			

CIRCULAR (TRIGONOMETRIC) FUNCTIONS.

RADIANS.	DEGREES.	SINES.		COSINES.		TANGENTS.		COTANGENTS.			
		Nat.	Log.	Nat.	Log.	Nat.	Log.	Nat.	Log.		
0.6283	36°00′	.5878	9.7692	.8090	9.9080	.7265	9.8613	1.3764	0.1387	54°00′	0.9425
0.6312	10	.5901	.7710	.8073	.9070	.7310	.8639	1.3680	.1361	50	0.9396
0.6341	20	.5925	.7727	.8056	.9061	.7355	.8666	1.3597	.1334	40	0.9367
0.6370	30	.5948	.7744	.8039	.9052	.7400	.8692	1.3514	.1308	30	0.9338
0.6400	40	.5972	.7761	.8021	.9042	.7445	.8718	1.3432	.1282	20	0.9308
0.6429	50	.5995	.7778	.8004	.9033	.7490	.8745	1.3351	.1255	10	0.9279
0.6458	37°00′	.6018	9.7795	.7986	9.9023	.7536	9.8771	1.3270	0.1229	53°00′	0.9250
0.6487	10	.6041	.7811	.7969	.9014	.7581	.8797	1.3190	.1203	50	0.9221
0.6516	20	.6065	.7828	.7951	.9004	.7627	.8824	1.3111	.1176	40	0.9192
0.6545	30	.6088	.7844	.7934	.8995	.7673	.8850	1.3032	.1150	30	0.9163
0.6574	40	.6111	.7861	.7916	.8985	.7720	.8876	1.2954	.1124	20	0.9134
0.6603	50	.6134	.7877	.7898	.8975	.7766	.8902	1.2876	.1098	10	0.9105
0.6632	38°00′	.6157	9.7893	.7880	9.8965	.7813	9.8928	1.2799	0.1072	52°00′	0.9076
0.6661	10	.6180	.7910	.7862	.8955	.7860	.8954	1.2723	.1046	50	0.9047
0.6690	20	.6202	.7926	.7844	.8945	.7907	.8980	1.2647	.1020	40	0.9018
0.6720	30	.6225	.7941	.7826	.8935	.7954	.9006	1.2572	.0994	30	0.8988
0.6749	40	.6248	.7957	.7808	.8925	.8002	.9032	1.2497	.0968	20	0.8959
0.6778	50	.6271	.7973	.7790	.8915	.8050	.9058	1.2423	.0942	10	0.8930
0.6807	39°00′	.6293	9.7989	.7771	9.8905	.8098	9.9084	1.2349	0.0916	51°00′	0.8901
0.6836	10	.6316	.8004	.7753	.8895	.8146	.9110	1.2276	.0890	50	0.8872
0.6865	20	.6338	.8020	.7735	.8884	.8195	.9135	1.2203	.0865	40	0.8843
0.6894	30	.6361	.8035	.7716	.8874	.8243	.9161	1.2131	.0839	30	0.8814
0.6923	40	.6383	.8050	.7698	.8864	.8292	.9187	1.2059	.0813	20	0.8785
0.6952	50	.6406	.8066	.7679	.8853	.8342	.9212	1.1988	.0788	10	0.8756
0.6981	40°00′	.6428	9.8081	.7660	9.8843	.8391	9.9238	1.1918	0.0762	50°00′	0.8727
0.7010	10	.6450	.8096	.7642	.8832	.8441	.9264	1.1847	.0736	50	0.8698
0.7039	20	.6472	.8111	.7623	.8821	.8491	.9289	1.1778	.0711	40	0.8668
0.7069	30	.6494	.8125	.7604	.8810	.8541	.9315	1.1708	.0685	30	0.8639
0.7098	40	.6517	.8140	.7585	.8800	.8591	.9341	1.1640	.0659	20	0.8610
0.7127	50	.6539	.8155	.7566	.8789	.8642	.9366	1.1571	.0634	10	0.8581
0.7156	41°00′	.6561	9.8169	.7547	9.8778	.8693	9.9392	1.1504	0.0608	49°00′	0.8552
0.7185	10	.6583	.8184	.7528	.8767	.8744	.9417	1.1436	.0583	50	0.8523
0.7214	20	.6604	.8198	.7509	.8756	.8796	.9443	1.1369	.0557	40	0.8494
0.7243	30	.6626	.8213	.7490	.8745	.8847	.9468	1.1303	.0532	30	0.8465
0.7272	40	.6648	.8227	.7470	.8733	.8899	.9494	1.1237	.0506	20	0.8436
0.7301	50	.6670	.8241	.7451	.8722	.8952	.9519	1.1171	.0481	10	0.8407
0.7330	42°00′	.6691	9.8255	.7431	9.8711	.9004	9.9544	1.1106	0.0456	48°00′	0.8378
0.7359	10	.6713	.8269	.7412	.8699	.9057	.9570	1.1041	.0430	50	0.8348
0.7389	20	.6734	.8283	.7392	.8688	.9110	.9595	1.0977	.0405	40	0.8319
0.7418	30	.6756	.8297	.7373	.8676	.9163	.9621	1.0913	.0379	30	0.8290
0.7447	40	.6777	.8311	.7353	.8665	.9217	.9646	1.0850	.0354	20	0.8261
0.7476	50	.6799	.8324	.7333	.8653	.9271	.9671	1.0786	.0329	10	0.8232
0.7505	43°00′	.6820	9.8338	.7314	9.8641	.9325	9.9697	1.0724	0.0303	47°00′	0.8203
0.7534	10	.6841	.8351	.7294	.8629	.9380	.9722	1.0661	.0278	50	0.8174
0.7563	20	.6862	.8365	.7274	.8618	.9435	.9747	1.0599	.0253	40	0.8145
0.7592	30	.6884	.8378	.7254	.8606	.9490	.9772	1.0538	.0228	30	0.8116
0.7621	40	.6905	.8391	.7234	.8594	.9545	.9798	1.0477	.0202	20	0.8087
0.7650	50	.6926	.8405	.7214	.8582	.9601	.9823	1.0416	.0177	10	0.8058
0.7679	44°00′	.6947	9.8418	.7193	9.8569	.9657	9.9848	1.0355	0.0152	46°00′	0.8029
0.7709	10	.6967	.8431	.7173	.8557	.9713	.9874	1.0295	.0126	50	0.7999
0.7738	20	.6988	.8444	.7153	.8545	.9770	.9899	1.0235	.0101	40	0.7970
0.7767	30	.7009	.8457	.7133	.8532	.9827	.9924	1.0176	.0076	30	0.7941
0.7796	40	.7030	.8469	.7112	.8520	.9884	.9949	1.0117	.0051	20	0.7912
0.7825	50	.7050	.8482	.7092	.8507	.9942	.9975	1.0058	.0025	10	0.7883
0.7854	45°00′	.7071	9.8495	.7071	9.8495	1.0000	0.0000	1.0000	0.0000	45°00′	0.7854
		Nat.	Log.	Nat	Log.	Nat.	Log.	Nat.	Log.	DEGREES.	RADIANS.
		COSINES.		SINES.		COTANGENTS.		TANGENTS.			

TABLE 12.

CIRCULAR (TRIGONOMETRIC) FUNCTIONS.*

RADIANS.	SINES.		COSINES.		TANGENTS.		COTANGENTS.		DEGREES.
	Nat.	Log.	Nat.	Log.	Nat.	Log.	Nat.	Log.	
0.00	0.00000	— ∞	1.00000	0.00000	— ∞	— ∞	.∞	∞	00°00′
.01	.01000	7.99999	0.99995	9.99998	0.01000	8.00001	99.997	1.99999	00 34
.02	.02000	8.30100	.99980	.99991	.02000	.30109	49.993	.69891	01 09
.03	.03000	.47706	.99955	.99980	.03001	.47725	33.323	.52275	01 43
.04	.03999	.60194	.99920	.99965	.04002	.60229	24.987	.39771	02 18
0.05	0.04998	8.69879	0.99875	9.99946	0.05004	8.69933	19.983	1.30067	02°52′
.06	.05996	.77789	.99820	.99922	.06007	.77867	16.647	.22133	03 26
.07	.06994	.84474	.99755	.99894	.07011	.84581	14.262	.15419	04 01
.08	.07991	.90263	.99680	.99861	.08017	.90402	12.473	.09598	04 35
.09	.08988	.95366	.99595	.99824	.09024	.95542	11.081	.04458	05 09
0.10	0.09983	8.99928	0.99500	9.99782	0.10033	9.00145	9.9666	0.99855	05°44′
.11	.10978	9.04052	.99396	.99737	.11045	.04315	9.0542	.95685	06 18
.12	.11971	.07814	.99281	.99687	.12058	.08127	8.2933	.91873	06 53
.13	.12963	.11272	.99156	.99632	.13074	.11640	7.6489	.88360	07 27
.14	.13954	.14471	.99022	.99573	.14092	.14898	7.0961	.85102	08 01
0.15	0.14944	9.17446	0.98877	9.99510	0.15114	9.17937	6.6166	0.82063	08°36′
.16	.15932	.20227	.98723	.99442	.16138	.20785	6.1966	.79215	09 10
.17	.16918	.22836	.98558	.99369	.17166	.23466	5.8256	.76534	09 44
.18	.17903	.25292	.98384	.99293	.18197	.26000	5.4954	.74000	10 19
.19	.18886	.27614	.98200	.99211	.19232	.28402	5.1997	.71598	10 53
0.20	0.19867	9.29813	0.98007	9.99126	0.20271	9.30688	4.9332	0.69312	11°28′
.21	.20846	.31902	.97803	.99035	.21314	.32867	4.6917	.67133	12 02
.22	.21823	.33891	.97590	.98940	.22362	.34951	4.4719	.65049	12 36
.23	.22798	.35789	.97367	.98841	.23414	.36948	4.2709	.63052	13 11
.24	.23770	.37603	.97134	.98737	.24472	.38866	4.0864	.61134	13 45
0.25	0.24740	9.39341	0.96891	9.98628	0.25534	9.40712	3.9163	0.59288	14°19′
.26	.25708	.41007	.96639	.98515	.26602	.42491	3.7592	.57509	14 54
.27	.26673	.42607	.96377	.98397	.27676	.44210	3.6133	.55790	15 28
.28	.27636	.44147	.96106	.98275	.28755	.45872	3.4776	.54128	16 03
.29	.28595	.45629	.95824	.98148	.29841	.47482	3.3511	.52518	16 37
0.30	0.29552	9.47059	0.95534	9.98016	0.30934	9.49043	3.2327	0.50957	17°11′
.31	.30506	.48438	.95233	.97879	.32033	.50559	3.1218	.49441	17 46
.32	.31457	.49771	.94924	.97737	.33139	.52034	3.0176	.47966	18 20
.33	.32404	.51060	.94604	.97591	.34252	.53469	2.9195	.46531	18 54
.34	.33349	.52308	.94275	.97440	.35374	.54868	2.8270	.45132	19 29
0.35	0.34290	9.53516	0.93937	9.97284	0.36503	9.56233	2.7395	0.43767	20°03′
.36	.35227	.54688	.93590	.97123	.37640	.57565	2.6567	.42435	20 38
.37	.36162	.55825	.93233	.96957	.38786	.58868	2.5782	.41132	21 12
.38	.37092	.56928	.92866	.96786	.39941	.60142	2.5037	.39858	21 46
.39	.38019	.58000	.92491	.96610	.41105	.61390	2.4328	.38610	22 21
0.40	0.38942	9.59042	0.92106	9.96429	0.42279	9.62613	2.3652	0.37387	22°55′
.41	.39861	.60055	.91712	.96243	.43463	.63812	2.3008	.36188	23 29
.42	.40776	.61041	.91309	.96051	.44657	.64989	2.2393	.35011	24 04
.43	.41687	.62000	.90897	.95855	.45862	.66145	2.1804	.33855	24 38
.44	.42594	.62935	.90475	.95653	.47078	.67282	2.1241	.32718	25 13
0.45	0.43497	9.63845	0.90045	9.95446	0.48306	9.68400	2.0702	0.31600	25°47′
.46	.44395	.64733	.89605	.95233	.49545	.69500	2.0184	.30500	26 21
.47	.45289	.65599	.89157	.95015	.50797	.70583	1.9686	.29417	26 56
.48	.46178	.66443	.88699	.94792	.52061	.71651	1.9208	.28349	27 30
.49	.47063	.67268	.88233	.94563	.53339	.72704	1.8748	.27296	28 04
0.50	0.47943	9.68072	0.87758	9.94329	0.54630	9.73743	1.8305	0.26257	28°39′

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* Arranged and computed by C. E. Van Orstrand.

CIRCULAR (TRIGONOMETRIC) FUNCTIONS.

RADIANS.	SINES.		COSINES.		TANGENTS.		COTANGENTS.		DEGREES.
	Nat.	Log.	Nat.	Log.	Nat.	Log.	Nat.	Log.	
0.50	0.47943	9.68072	0.87758	9.94329	0.54630	9.73743	1.8305	0.26257	28°39′
.51	.48818	.68858	.87274	.94089	.55936	.74769	.7878	.25231	29 13
.52	.49688	.69625	.86782	.93843	.57256	.75782	.7465	.24218	29 48
.53	.50553	.70375	.86281	.93591	.58592	.76784	.7067	.23216	30 22
.54	.51414	.71108	.85771	.93334	.59943	.77774	.6683	.22226	30 56
0.55	0.52269	9.71824	0.85252	9.93071	0.61311	9.78754	1.6310	0.21246	31°31′
.56	.53119	.72525	.84726	.92801	.62695	.79723	.5950	.20277	32 05
.57	.53963	.73210	.84190	.92526	.64097	.80684	.5601	.19316	32 40
.58	.54802	.73880	.83646	.92245	.65517	.81635	.5263	.18365	33 14
.59	.55636	.74536	.83094	.91957	.66956	.82579	.4935	.17421	33 48
0.60	0.56464	9.75177	0.82534	9.91663	0.68414	9.83514	1.4617	0.16486	34°23′
.61	.57287	.75805	.81965	.91363	.69892	.84443	.4308	.15557	34 57
.62	.58104	.76420	.81388	.91056	.71391	.85364	.4007	.14636	35 31
.63	.58914	.77022	.80803	.90743	.72911	.86280	.3715	.13720	36 06
.64	.59720	.77612	.80210	.90423	.74454	.87189	.3431	.12811	36 40
0.65	0.60519	9.78189	0.79608	9.90096	0.76020	9.88093	1.3154	0.11907	37°15′
.66	.61312	.78754	.78999	.89762	.77610	.88992	.2885	.11008	37 49
.67	.62099	.79308	.78382	.89422	.79225	.89886	.2622	.10114	38 23
.68	.62879	.79851	.77757	.89074	.80866	.90777	.2366	.09223	38 58
.69	.63654	.80382	.77125	.88719	.82534	.91663	.2116	.08337	39 32
0.70	0.64422	9.80903	0.76484	9.88357	0.84229	9.92546	1.1872	0.07454	40°06′
.71	.65183	.81414	.75836	.87988	.85953	.93426	.1634	.06574	40 41
.72	.65938	.81914	.75181	.87611	.87707	.94303	.1402	.05697	41 15
.73	.66687	.82404	.74517	.87226	.89492	.95178	.1174	.04822	41 50
.74	.67429	.82885	.73847	.86833	.91309	.96051	.0952	.03949	42 24
0.75	0.68164	9.83355	0.73169	9.86433	0.93160	9.96923	1.0734	0.03077	42°58′
.76	.68892	.83817	.72484	.86024	.95045	.97793	.0521	.02207	43 33
.77	.69614	.84269	.71791	.85607	.96967	.98662	.0313	.01338	44 07
.78	.70328	.84713	.71091	.85182	.98926	9.99531	1.0109	.00469	44 41
.79	.71035	.85147	.70385	.84748	1.0092	0.00400	0.99084	9.99600	45 16
0.80	0.71736	9.85573	0.69671	9.84305	1.0296	0.01268	0.97121	9.98732	45°50′
.81	.72429	.85991	.68950	.83853	.0505	.02138	.95197	.97862	46 28
.82	.73115	.86400	.68222	.83393	.0717	.03008	.93309	.96992	46 59
.83	.73793	.86802	.67488	.82922	.0934	.03879	.91455	.96121	47 33
.84	.74464	.87195	.66746	.82443	.1156	.04752	.89635	.95248	48 08
0.85	0.75128	9.87580	0.65998	9.81953	1.1383	0.05627	0.87848	9.94373	48°42′
.86	.75784	.87958	.65244	.81454	.1616	.06504	.86091	.93496	49 16
.87	.76433	.88328	.64483	.80944	.1853	.07384	.84365	.92616	49 51
.88	.77074	.88691	.63715	.80424	.2097	.08266	.82668	.91734	50 25
.89	.77707	.89046	.62941	.79894	.2346	.09153	.80998	.90847	51 00
0.90	0.78333	9.89394	0.62161	9.79352	1.2602	0.10043	0.79355	9.89957	51°34′
.91	.78950	.89735	.61375	.78799	.2864	.10937	.77738	.89063	52 08
.92	.79560	.90070	.60582	.78234	.3133	.11835	.76146	.88165	52 43
.93	.80162	.90397	.59783	.77658	.3409	.12739	.74578	.87261	53 17
.94	.80756	.90717	.58979	.77070	.3692	.13648	.73034	.86352	53 51
0.95	0.81342	9.91031	0.58168	9.76469	1.3984	0.14563	0.71511	9.85437	54°26′
.96	.81919	.91339	.57352	.75855	.4284	.15484	.70010	.84516	55 00
.97	.82489	.91639	.56530	.75228	.4592	.16412	.68531	.83588	55 35
.98	.83050	.91934	.55702	.74587	.4910	.17347	.67071	.82653	56 09
.99	.83603	.92222	.54869	.73933	.5237	.18289	.65631	.81711	56 43
1.00	0.84147	9.92504	0.54030	9.73264	1.5574	0.19240	0.64209	9.80760	57°18′

CIRCULAR (TRIGONOMETRIC) FUNCTIONS.

RADIANS.	SINES.		COSINES.		TANGENTS.		COTANGENTS.		DEGREES.
	Nat.	Log.	Nat.	Log.	Nat.	Log.	Nat.	Log.	
1.00	0.84147	9.92504	0.54030	9.73264	1.5574	0.19240	0.64209	9.80760	57°18′
.01	.84683	.92780	.53186	.72580	.5922	.20200	.62806	.79800	57 52
.02	.85211	.93049	.52337	.71881	.6281	.21169	.61420	.78831	58 27
.03	.85730	.93313	.51482	.71165	.6652	.22148	.60051	.77852	59 01
.04	.86240	.93571	.50622	.70434	.7036	.23137	.58699	.76863	59 35
1.05	0.86742	9.93823	0.49757	9.69686	1.7433	0.24138	0.57362	9.75862	60°10′
.06	.87236	.94069	.48887	.68920	.7844	.25150	.56040	.74850	60 44
.07	.87720	.94310	.48012	.68135	.8270	.26175	.54734	.73825	61 18
.08	.88196	.94545	.47133	.67332	.8712	.27212	.53441	.72788	61 53
.09	.88663	.94774	.46249	.66510	.9171	.28264	.52162	.71736	62 27
1.10	0.89121	9.94998	0.45360	9.65667	1.9648	0.29331	0.50897	9.70669	63°02′
.11	.89570	.95216	.44466	.64803	2.0143	.30413	.49644	.69587	63 36
.12	.90010	.95429	.43568	.63917	.0660	.31512	.48404	.68488	64 10
.13	.90441	.95637	.42666	.63008	.1197	.32628	.47175	.67372	64 45
.14	.90863	.95839	.41759	.62075	.1759	.33763	.45959	.66237	65 19
1.15	0.91276	9.96036	0.40849	9.61118	2.2345	0.34918	0.44753	9.65082	65°53′
.16	.91680	.96228	.39934	.60134	.2958	.36093	.43558	.63907	66 28
.17	.92075	.96414	.39015	.59123	.3600	.37291	.42373	.62709	67 02
.18	.92461	.96596	.38092	.58084	.4273	.38512	.41199	.61488	67 37
.19	.92837	.96772	.37166	.57015	.4979	.39757	.40034	.60243	68 11
1.20	0.93204	9.96943	0.36236	9.55914	2.5722	0.41030	0.38878	9.58970	68°45′
.21	.93562	.97110	.35302	.54780	.6503	.42330	.37731	.57670	69 20
.22	.93910	.97271	.34365	.53611	.7328	.43660	.36593	.56340	69 54
.23	.94249	.97428	.33424	.52406	.8198	.45022	.35463	.54978	70 28
.24	.94578	.97579	.32480	.51161	.9119	.46418	.34341	.53582	71 03
1.25	0.94898	9.97726	0.31532	9.49875	3.0096	0.47850	0.33227	9.52150	71°37′
.26	.95209	.97868	.30582	.48546	.1133	.49322	.32121	.50678	72 12
.27	.95510	.98005	.29628	.47170	.2236	.50835	.31021	.49165	72 46
.28	.95802	.98137	.28672	.45745	.3413	.52392	.29928	.47608	73 20
.29	.96084	.98265	.27712	.44267	.4672	.53998	.28842	.46002	73 55
1.30	0.96356	9.98388	0.26750	9.42732	3.6021	0.55656	0.27762	9.44344	74°29′
.31	.96618	.98506	.25785	.41137	.7471	.57369	.26687	.42631	75 03
.32	.96872	.98620	.24818	.39476	.9033	.59144	.25619	.40856	75 38
.33	.97115	.98729	.23848	.37744	4.0723	.60984	.24556	.39016	76 12
.34	.97348	.98833	.22875	.35937	.2556	.62896	.23498	.37104	76 47
1.35	0.97572	9.98933	0.21901	9.34046	4.4552	0.64887	0.22446	9.35113	77°21′
.36	.97786	.99028	.20924	.32064	.6734	.66964	.21398	.33036	77 55
.37	.97991	.99119	.19945	.29983	.9131	.69135	.20354	.30865	78 30
.38	.98185	.99205	.18964	.27793	5.1774	.71411	.19315	.28589	79 04
.39	.98370	.99286	.17981	.25482	.4707	.73804	.18279	.26196	79 38
1.40	0.98545	9.99363	0.16997	9.23036	5.7979	0.76327	0.17248	9.23673	80°13′
.41	.98710	.99436	.16010	.20440	6.1654	.78996	.16220	.21004	80 47
.42	.98865	.99504	.15023	.17674	6.5811	.81830	.15195	.18170	81 22
.43	.99010	.99568	.14033	.14716	7.0555	.84853	.14173	.15147	81 56
.44	.99146	.99627	.13042	.11536	7.6018	.88092	.13155	.11908	82 30
1.45	0.99271	9.99682	0.12050	9.08100	8.2381	0.91583	0.12139	9.08417	83°05′
.46	.99387	.99733	.11057	.04364	8.9886	.95369	.11125	.04631	83 39
.47	.99492	.99779	.10063	.00271	9.8874	.99508	.10114	.00492	84 13
.48	.99588	.99821	.09067	8.95747	10.983	1.04074	.09105	8.95926	84 48
.49	.99674	.99858	.08071	.90692	12.350	.09166	.08097	.90834	85 22
1.50	0.99749	9.99891	0.07074	8.84965	14.101	1.14926	0.07091	8.85074	85°57′

TABLE 12 (*continued*). — Circular (Trigonometric) Functions.

RADIANS.	SINES.		COSINES.		TANGENTS.		COTANGENTS.		DEGREES.
	Nat.	Log.	Nat.	Log.	Nat.	Log.	Nat.	Log.	
1.50	0.99749	9.99891	0.07074	8.84965	14.101	1.14926	0.07091	8.85074	85°57′
.51	.99815	.99920	.06076	.78361	16.428	.21559	.06087	.78441	86 31
.52	.99871	.99944	.05077	.70565	19.670	.29379	.05084	.70621	87 05
.53	.99917	.99964	.04079	.61050	24.498	.38914	.04082	.61086	87 40
.54	.99953	.99979	.03079	.48843	32.461	.51136	.03081	.48864	88 14
1.55	0.99978	9.99991	0.02079	8.31796	48.078	1.68195	0.02080	8.31805	88°49′
.56	0.99994	9.99997	.01080	8.03327	92.621	1.96671	.01080	8.03330	89 23
.57	1.00000	0.00000	.00080	6.90109	1255.8	3.09891	.00080	6.90109	89 57
.58	0.99996	9.99998	−.00920	7.96396n	108.65	2.03603	−.00920	7.96397n	90 32
.59	0.99982	9.99992	−.01920	8.28336n	52.067	1.71656	−.01921	8.28344n	91 06
1.60	0.99957	9.99981	−0.02920	8.46538n	34.233	1.53444	−0.02921	8.46556n	91°40′

90° = 1.570 7963 radians.

TABLE 12a. — Factorials.

Logarithms of the products 1.2.3. . . . . . . *n*, *n* from 1 to 100.

See Table 30 for log. Γ (*n* + 1), values of *n* between 1 and 2.

n.	log.(*n!*)	*n*.	log.(*n!*)	*n*.	log.(*n!*)	*n*.	log.(*n!*)
1	0.000000	**26**	26.605619	**51**	66.190645	**76**	111.275425
2	0.301029	27	28.036982	52	67.906648	77	113.161916
3	0.778151	28	29.484140	53	69.630924	78	115.054010
4	1.380211	29	30.946538	54	71.363318	79	116.951637
5	2.079181	30	32.423660	55	73.103680	80	118.854727
6	2.857332	**31**	33.915021	**56**	74.851868	**81**	120.763212
7	3.702430	32	35.420171	57	76.607743	82	122.677026
8	4.605520	33	36.938685	58	78.371171	83	124.596104
9	5.559763	34	38.470164	59	80.142023	84	126.520383
10	6.559763	35	40.014232	60	81.920174	85	128.449802
11	7.601155	**36**	41.570535	**61**	83.705504	**86**	130.384301
12	8.680336	37	43.138736	62	85.497896	87	132.323820
13	9.794280	38	44.718520	63	87.297236	88	134.268303
14	10.940408	39	46.309585	64	89.103416	89	136.217693
15	12.116499	40	47.911645	65	90.916330	90	138.171935
16	13.320619	**41**	49.524428	**66**	92.735874	**91**	140.130977
17	14.551068	42	51.147678	67	94.561948	92	142.094765
18	15.806341	43	52.781146	68	96.394457	93	144.063247
19	17.085094	44	54.424599	69	98.233306	94	146.036375
20	18.386124	45	56.077811	70	100.078405	95	148.014099
21	19.708343	**46**	57.740569	**71**	101.929663	**96**	149.996370
22	21.050766	47	59.412667	72	103.786995	97	151.983142
23	22.412494	48	61.093908	73	105.650318	98	153.974368
24	23.792705	49	62.784104	74	107.519550	99	155.970003
25	25.190645	50	64.483074	75	109.394611	100	157.970003

TABLE 13.

HYPERBOLIC FUNCTIONS.*

Hyperbolic sines. Values of $\frac{e^x - e^{-x}}{2}$.

x	0	1	2	3	4	5	6	7	8	9
0.0	0.0000	0.0100	0.0200	0.0300	0.0400	0.0500	0.0600	0.0701	0.0801	0.0901
0.1	.1002	.1102	.1203	.1304	.1405	.1506	.1607	.1708	.1810	.1911
0.2	.2013	.2115	.2218	.2320	.2423	.2526	.2629	.2733	.2837	.2941
0.3	.3045	.3150	.3255	.3360	.3466	.3572	.3678	.3785	.3892	.4000
0.4	.4108	.4216	.4325	.4434	.4543	.4653	.4764	.4875	.4986	.5098
0.5	0.5211	0.5324	0.5438	0.5552	0.5666	0.5782	0.5897	0.6014	0.6131	0.6248
0.6	.6367	.6485	.6605	.6725	.6846	.6967	.7090	.7213	.7336	.7461
0.7	.7586	.7712	.7838	.7966	.8094	.8223	.8353	.8484	.8615	.8748
0.8	.8881	.9015	.9150	.9286	.9423	.9561	.9700	.9840	.9981	.0122
0.9	1.0265	1.0409	1.0554	1.0700	1.0847	1.0995	1.1144	1.1294	1.1446	1.1598
1.0	1.1752	1.1907	1.2063	1.2220	1.2379	1.2539	1.2700	1.2862	1.3025	1.3190
1.1	.3356	.3524	.3693	.3863	.4035	.4208	.4382	.4558	.4735	.4914
1.2	.5095	.5276	.5460	.5645	.5831	.6019	.6209	.6400	.6593	.6788
1.3	.6984	.7182	.7381	.7583	.7786	.7991	.8198	.8406	.8617	.8829
1.4	.9043	.9259	.9477	.9697	.9919	2.0143	2.0369	2.0597	2.0827	2.1059
1.5	2.1293	2.1529	2.1768	2.2008	2.2251	2.2496	2.2743	2.2993	2.3245	2.3499
1.6	.3756	.4015	.4276	.4540	.4806	.5075	.5346	.5620	.5896	.6175
1.7	.6456	.6740	.7027	.7317	.7609	.7904	.8202	.8503	.8806	.9112
1.8	.9422	.9734	3.0049	3.0367	3.0689	3.1013	3.1340	3.1671	3.2005	3.2341
1.9	3.2682	3.3025	.3372	.3722	.4075	.4432	.4792	.5156	.5523	.5894
2.0	3.6269	3.6647	3.7028	3.7414	3.7803	3.8196	3.8593	3.8993	3.9398	3.9806
2.1	4.0219	4.0635	4.1056	4.1480	4.1909	4.2342	4.2779	4.3221	4.3666	4.4117
2.2	4.4571	4.5030	4.5494	4.5962	4.6434	4.6912	4.7394	4.7880	4.8372	4.8868
2.3	4.9370	4.9876	5.0387	5.0903	5.1425	5.1951	5.2483	5.3020	5.3562	5.4109
2.4	5.4662	5.5221	5.5785	5.6354	5.6929	5.7510	5.8097	5.8689	5.9288	5.9892
2.5	6.0502	6.1118	6.1741	6.2369	6.3004	6.3645	6.4293	6.4946	6.5607	6.6274
2.6	6.6947	6.7628	6.8315	6.9009	6.9709	7.0417	7.1132	7.1854	7.2583	7.3319
2.7	7.4063	7.4814	7.5572	7.6338	7.7112	7.7894	7.8683	7.9480	8.0285	8.1098
2.8	8.1919	8.2749	8.3586	8.4432	8.5287	8.6150	8.7021	8.7902	8.8791	8.9689
2.9	9.0596	9.1512	9.2437	9.3371	9.4315	9.5268	9.6231	9.7203	9.8185	9.9177
3.0	10.018	10.119	10.221	10.324	11.429	11.534	11.640	11.748	11.856	11.966
3.1	11.076	11.188	11.301	11.415	11.530	12.647	12.764	12.883	12.003	12.124
3.2	12.246	12.369	12.494	12.620	12.747	12.876	13.006	13.137	13.269	13.403
3.3	13.538	13.674	13.812	13.951	14.092	14.234	14.377	14.522	14.668	14.816
3.4	14.965	15.116	15.268	15.422	15.577	15.734	15.893	16.053	16.214	16.378
3.5	16.543	16.709	16.877	17.047	17.219	17.392	17.567	17.744	17.923	18.103
3.6	18.285	18.470	18.655	18.843	19.033	19.224	19.418	19.613	19.811	20.010
3.7	20.211	20.415	20.620	20.828	21.037	21.249	21.463	21.679	21.897	22.117
3.8	22.339	22.564	22.791	23.020	23.252	23.486	23.722	23.961	24.202	24.445
3.9	24.691	24.939	25.190	25.444	25.700	25.958	26.219	26.483	26.749	27.018
4.0	27.290	27.564	27.842	28.122	28.404	28.690	28.979	29.270	29.564	29.862
4.1	30.162	30.465	30.772	31.081	31.393	31.709	32.028	32.350	32.675	33.004
4.2	33.336	33.671	34.009	34.351	34.697	35.046	35.398	35.754	36.113	36.476
4.3	36.843	37.214	37.588	37.966	38.347	38.733	39.122	39.515	39.913	40.314
4.4	40.719	41.129	41.542	41.960	42.382	42.808	43.238	43.673	44.112	44.555
4.5	45.003	45.455	45.912	46.374	46.840	47.311	47.787	48.267	48.752	49.242
4.6	49.737	50.237	50.742	51.252	51.767	52.288	52.813	53.344	53.880	54.422
4.7	54.969	55.522	56.080	56.643	57.213	57.788	58.369	58.955	59.548	60.147
4.8	60.751	61.362	61.979	62.601	63.231	63.866	64.508	65.157	65.812	66.473
4.9	67.141	67.816	68.498	69.186	69.882	70.584	71.293	72.010	72.734	73.465

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* Tables 38–41 are quoted from "Des Ingenieurs Taschenbuch," herausgegeben vom Akademischen Verein (Hütte).

TABLE 14.

HYPERBOLIC FUNCTIONS.

Common logarithms + 10 of the hyperbolic sines.

x	0	1	2	3	4	5	6	7	8	9
0.0	— ∞	8.0000	3011	4772	6022	6992	7784	8455	9036	9548
0.1	9.0007	0423	0802	1152	1475	1777	2060	2325	2576	2814
0.2	3039	3254	3459	3656	3844	4025	4199	4366	4528	4685
0.3	4836	4983	5125	5264	5398	5529	5656	5781	5902	6020
0.4	9.6136	6249	6359	6468	6574	6678	6780	6880	6978	7074
0.5	9.7169	7262	7354	7444	7533	7620	7707	7791	7875	7958
0.6	8039	8119	8199	8277	8354	8431	8506	8581	8655	8728
0.7	8800	8872	8942	9012	9082	9150	9218	9286	9353	9419
0.8	9485	9550	9614	9678	9742	9805	9868	9930	9992	0053
0.9	10.0114	0174	0234	0294	0353	0412	0470	0529	0586	0644
1.0	10.0701	0758	0815	0871	0927	0982	1038	1093	1148	1203
1.1	1257	1311	1365	1419	1472	1525	1578	1631	1684	1736
1.2	1788	1840	1892	1944	1995	2046	2098	2148	2199	2250
1.3	2300	2351	2401	2451	2501	2551	2600	2650	2699	2748
1.4	2797	2846	2895	2944	2993	3041	3090	3138	3186	3234
1.5	10.3282	3330	3378	3426	3474	3521	3569	3616	3663	3711
1.6	3758	3805	3852	3899	3946	3992	4039	4086	4132	4179
1.7	4225	4272	4318	4364	4411	4457	4503	4549	4595	4641
1.8	4687	4733	4778	4824	4870	4915	4961	5007	5052	5098
1.9	5143	5188	5234	5279	5324	5370	5415	5460	5505	5550
2.0	10.5595	5640	5685	5730	5775	5820	5865	5910	5955	5999
2.1	6044	6089	6134	6178	6223	6268	6312	6357	6401	6446
2.2	6491	6535	6580	6624	6668	6713	6757	6802	6846	6890
2.3	6935	6979	7023	7067	7112	7156	7200	7244	7289	7333
2.4	7377	7421	7465	7509	7553	7597	7642	7686	7730	7774
2.5	10.7818	7862	7906	7950	7994	8038	8082	8126	8169	8213
2.6	8257	8301	8345	8389	8433	8477	8521	8564	8608	8652
2.7	8696	8740	8784	8827	8871	8915	8959	9003	9046	9090
2.8	9134	9178	9221	9265	9309	9353	9396	9440	9484	9527
2.9	9571	9615	9658	9702	9746	9789	9833	9877	9920	9964
3.0	11.0008	0051	0095	0139	0182	0226	0270	0313	0357	0400
3.1	0444	0488	0531	0575	0618	0662	0706	0749	0793	0836
3.2	0880	0923	0967	1011	1054	1098	1141	1185	1228	1272
3.3	1316	1359	1403	1446	1490	1533	1577	1620	1664	1707
3.4	1751	1794	1838	1881	1925	1968	2012	2056	2099	2143
3.5	11.2186	2230	2273	2317	2360	2404	2447	2491	2534	2578
3.6	2621	2665	2708	2752	2795	2839	2882	2925	2969	3012
3.7	3056	3099	3143	3186	3230	3273	3317	3360	3404	3447
3.8	3491	3534	3578	3621	3665	3708	3752	3795	3838	3882
3.9	3925	3969	4012	4056	4099	4143	4186	4230	4273	4317
4.0	11.4360	4403	4447	4490	4534	4577	4621	4664	4708	4751
4.1	4795	4838	4881	4925	4968	5012	5055	5099	5142	5186
4.2	5229	5273	5316	5359	5403	5446	5490	5533	5577	5620
4.3	5664	5707	5750	5794	5837	5881	5924	5968	6011	6055
4.4	6098	6141	6185	6228	6272	6315	6359	6402	6446	6489
4.5	11.6532	6576	6619	6663	6706	6750	6793	6836	6880	6923
4.6	6967	7010	7054	7097	7141	7184	7227	7271	7314	7358
4.7	7401	7445	7488	7531	7575	7618	7662	7705	7749	7792
4.8	7836	7879	7922	7966	8009	8053	8096	8140	8183	8226
4.9	8270	8313	8357	8400	8444	8487	8530	8574	8617	8661

Table 15.

HYPERBOLIC FUNCTIONS.

Hyperbolic cosines. **Values of $\frac{e^x + e^{-x}}{2}$.**

x	0	1	2	3	4	5	6	7	8	9
0.0	1.0000	1.0001	1.0002	1.0005	1.0008	1.0013	1.0018	1.0025	1.0032	1.0041
0.1	.0050	.0061	.0072	.0085	.0098	.0113	.0128	.0145	.0162	.0181
0.2	.0201	.0221	.0243	.0266	.0289	.0314	.0340	.0367	.0395	.0423
0.3	.0453	.0484	.0516	.0549	.0584	.0619	.0655	.0692	.0731	.0770
0.4	.0811	.0852	.0895	.0939	.0984	.1030	.1077	.1125	.1174	.1225
0.5	1.1276	1.1329	1.1383	1.1438	1.1494	1.1551	1.1609	1.1669	1.1730	1.1792
0.6	.1855	.1919	.1984	.2051	.2119	.2188	.2258	.2330	.2402	.2476
0.7	.2552	.2628	.2706	.2785	.2865	.2947	.3030	.3114	.3199	.3286
0.8	.3374	.3464	.3555	.3647	.3740	.3835	.3932	.4029	.4128	.4229
0.9	.4331	4434	.4539	.4645	.4753	.4862	.4973	.5085	.5199	.5314
1.0	1.5431	1.5549	1.5669	1.5790	1.5913	1.6038	.6164	1.6292	1.6421	1.6552
1.1	.6685	.6820	.6956	.7093	.7233	.7374	.7517	.7662	.7808	.7956
1.2	.8107	.8258	.8412	.8568	.8725	.8884	.9045	.9208	.9373	.9540
1.3	.9709	.9880	2.0053	2.0228	2.0404	2.0583	2.0764	2.0947	2.1132	2.1320
1.4	2.1509	.1700	.1894	.2090	.2288	.2488	.2691	.2896	.3103	.3312
1.5	2.3524	2.3738	2.3955	2.4174	2.4395	2.4619	2.4845	2.5073	2.5305	2.5538
1.6	.5775	.6013	.6255	.6499	.6746	.6995	.7247	.7502	.7760	.8020
1.7	.8283	.8549	.8818	.9090	.9364	.9642	.9922	3.0206	3.0492	3.0782
1.8	3.1075	3.1371	3.1669	3.1972	3.2277	3.2585	3.2897	.3212	.3530	.3852
1.9	.4177	.4506	.4838	.5173	.5512	.5855	.6201	.6551	.6904	.7261
2.0	3.7622	3.7987	3.8355	3.8727	3.9103	3.9483	3.9867	4.0255	4.0647	4.1043
2.1	4.1443	4.1847	4.2256	4.2668	4.3085	4.3507	4.3932	4.4362	4.4797	4.5236
2.2	4.5679	4.6127	4.6580	4.7037	4.7499	4.7966	4.8437	4.8914	4.9395	4.9881
2.3	5.0372	5.0868	5.1370	5.1876	5.2388	5.2905	5.3427	5.3954	5.4487	5.5026
2.4	5.5569	5.6119	5.6674	5.7235	5.7801	5.8373	5.8951	5.9535	6.0125	6.0721
2.5	6.1323	6.1931	6.2545	6.3166	6.3793	6.4426	6.5066	6.5712	6.6365	6.7024
2.6	6.7690	6.8363	6.9043	6.9729	7.0423	7.1123	7.1831	7.2546	7.3268	7.3998
2.7	7.4735	7.5479	7.6231	7.6990	7.7758	7.8533	7.9316	8.0106	8.0905	8.1712
2.8	8.2527	8.3351	8.4182	8.5022	8.5871	8.6728	8.7594	8.8469	8.9352	9.0244
2.9	9.1146	9.2056	9.2976	9.3905	9.4844	9.5791	9.6749	9.7716	9.8693	9.9680
3.0	10.068	10.168	10.270	10.373	10.476	10.581	10.687	10.794	10.902	11.011
3.1	11.121	12.233	11.345	11.459	11.574	11.689	11.806	11.925	12.044	12.165
3.2	12.287	12.410	12.534	12.660	12.786	12.915	13.044	13.175	13.307	13.440
3.3	13.575	13.711	13.848	13.987	14.127	14.269	14.412	14.556	14.702	14.850
3.4	14.999	15.149	15.301	15.455	15.610	15.766	15.924	16.084	16.245	16.408
3.5	16.573	16.739	16.907	17.077	17.248	17.421	17.596	17.772	17.951	18.131
3.6	18.313	18.497	18.682	18.870	19.059	19.250	19.444	19.639	19.836	20.035
3.7	20.236	20.439	20.644	20.852	21.061	21.272	21.486	21.702	21.919	22.139
3.8	22.362	22.586	22.813	23.042	23.273	23.507	23.743	23.982	24.222	24.466
3.9	24.711	24.959	25.210	25.463	25.719	25.977	26.238	26.502	26.768	27.037
4.0	27.308	27.582	27.860	28.139	28.422	28.707	28.996	29.287	29.581	29.878
4.1	30.178	30.482	30.788	31.097	31.409	31.725	32.044	32.365	32.691	33.019
4.2	33.351	33.686	34.024	34.366	34.711	35.060	35.412	35.768	36.127	36.490
4.3	36.857	37.227	37.601	37.979	38.360	38.746	39.135	39.528	39.925	40.326
4.4	40.732	41.141	41.554	41.972	42.393	42.819	43.250	43.684	44.123	44.566
4.5	45.014	45.466	45.923	46.385	46.851	47.321	47.797	48.277	48.762	49.252
4.6	49.747	50.247	50.752	51.262	51.777	52.297	52.823	53.354	53.890	54.431
4.7	54.978	55.531	56.089	56.652	57.221	57.796	58.377	58.964	59.556	60.155
4.8	60.759	61.370	61.987	62.609	63.239	63.874	64.516	65.164	65.819	66.481
4.9	67.149	67.823	68.505	69.193	69.889	70.591	71.300	72.017	72.741	73.472

TABLE 16.

HYPERBOLIC FUNCTIONS.

Common logarithms of the hyperbolic cosines.

x	0	1	2	3	4	5	6	7	8	9
0.0	0.0000	0000	0001	0002	0003	0005	0008	0011	0014	0018
0.1	0022	0026	0031	0037	0042	0049	0055	0062	0070	0078
0.2	0086	0095	0104	0114	0124	0134	0145	0156	0168	0180
0.3	0193	0205	0219	0232	0246	0261	0276	0291	0306	0322
0.4	0339	0355	0372	0390	0407	0426	0444	0463	0482	0502
0.5	0.0522	0542	0562	0583	0605	0626	0648	0670	0693	0716
0.6	0739	0762	0786	0810	0835	0859	0884	0910	0935	0961
0.7	0987	1013	1040	1067	1094	1122	1149	1177	1206	1234
0.8	1263	1292	1321	1350	1380	1410	1440	1470	1501	1532
0.9	1563	1594	1625	1657	1689	1721	1753	1785	1818	1851
1.0	0.1884	1917	1950	1984	2018	2051	2086	2120	2154	2189
1.1	2223	2258	2293	2328	2364	2399	2435	2470	2506	2542
1.2	2578	2615	2651	2688	2724	2761	2798	2835	2872	2909
1.3	2947	2984	3022	3059	3097	3135	3173	3211	3249	3288
1.4	3326	3365	3403	3442	3481	3520	3559	3598	3637	3676
1.5	0.3715	3754	3794	3833	3873	3913	3952	3992	4032	4072
1.6	4112	4152	4192	4232	4273	4313	4353	4394	4434	4475
1.7	4515	4556	4597	4637	4678	4719	4760	4801	4842	4883
1.8	4924	4965	5006	5048	5089	5130	5172	5213	5254	5296
1.9	5337	5379	5421	5462	5504	5545	5587	5629	5671	5713
2.0	0.5754	5796	5838	5880	5922	5964	6006	6048	6090	6132
2.1	6175	6217	6259	6301	6343	6386	6428	6470	6512	6555
2.2	6597	6640	6682	6724	6767	6809	6852	6894	6937	6979
2.3	7022	7064	7107	7150	7192	7235	7278	7320	7363	7406
2.4	7448	7491	7534	7577	7619	7662	7705	7748	7791	7833
2.5	0.7876	7919	7962	8005	8048	8091	8134	8176	8219	8262
2.6	8305	8348	8391	8434	8477	8520	8563	8606	8649	8692
2.7	8735	8778	8821	8864	8907	8951	8994	9037	9080	9123
2.8	9166	9209	9252	9295	9338	9382	9425	9468	9511	9554
2.9	9597	9641	9684	9727	9770	9813	9856	9900	9943	9986
3.0	1.0029	0073	0116	0159	0202	0245	0289	0332	0375	0418
3.1	0462	0505	0548	0591	0635	0678	0721	0764	0808	0851
3.2	0894	0938	0981	1024	1067	1111	1154	1197	1241	1284
3.3	1327	1371	1414	1457	1501	1544	1587	1631	1674	1717
3.4	1761	1804	1847	1891	1934	1977	2021	2064	2107	2151
3.5	1.2194	2237	2281	2324	2367	2411	2454	2497	2541	2584
3.6	2628	2671	2714	2758	2801	2844	2888	2931	2974	3018
3.7	3061	3105	3148	3191	3235	3278	3322	3365	3408	3452
3.8	3495	3538	3582	3625	3669	3712	3755	3799	3842	3886
3.9	3929	3972	4016	4059	4103	4146	4189	4233	4278	4320
4.0	1.4363	4406	4450	4493	4537	4580	4623	4667	4710	4754
4.1	4797	4840	4884	4927	4971	5014	5057	5101	5144	5188
4.2	5231	5274	5318	5361	5405	5448	5492	5535	5578	5622
4.3	5665	5709	5752	5795	5839	5882	5926	5969	6012	6056
4.4	6099	6143	6186	6230	6273	6316	6360	6403	6447	6490
4.5	1.6533	6577	6620	6664	6707	6751	6794	6837	6881	6924
4.6	6968	7011	7055	7098	7141	7185	7228	7272	7315	7358
4.7	7402	7445	7489	7532	7576	7619	7662	7706	7749	7793
4.8	7836	7880	7923	7966	8010	8053	8097	8140	8184	8227
4.9	8270	8314	8357	8401	8444	8487	8531	8574	8618	8661

TABLE 17.

EXPONENTIAL FUNCTIONS.

Values of e^x and e^{-x} intermediate to those here given may be found by adding or subtracting the values of the hyperbolic cosine and sine given in Tables 15 and 13.

x	$\log_{10}(e^x)$	e^x	e^{-x}	x	$\log_{10}(e^x)$	e^x	e^{-x}
0.0	0.00000	1.0000	1.000000	**5.0**	2.17147	148.41	0.006738
.1	.04343	.1052	0.904837	.1	.21490	164.02	.006097
.2	.08686	.2214	.818731	.2	.25833	181.27	.005517
.3	.13029	.3499	.740818	.3	.30176	200.34	.004992
.4	.17372	.4918	.670320	.4	.34519	221.41	.004517
0.5	0.21715	1.6487	0.606531	**5.5**	2.38862	244.69	0.004087
.6	.26058	.8221	.548812	.6	.43205	270.43	.003698
.7	.30401	2.0138	.496585	.7	.47548	298.87	.003346
.8	.34744	.2255	.449329	.8	.51891	330.30	.003028
.9	.39087	.4596	.406570	.9	.56234	365.04	.002739
1.0	0.43429	2.7183	0.367879	**6.0**	2.60577	403.43	0.002479
.1	.47772	3.0042	.332871	.1	.64920	445.86	.002243
.2	.52115	.3201	.301194	.2	.69263	492.75	.002029
.3	.56458	.6693	.272532	.3	.73606	544.57	.001836
.4	.60801	4.0552	.246597	.4	.77948	601.85	.001662
1.5	0.65144	4.4817	0.223130	**6.5**	2.82291	665.14	0.001503
.6	.69487	.9530	.201897	.6	.86634	735.10	.001360
.7	.73830	5.4739	.182684	.7	.90977	812.41	.001231
.8	.78173	6.0496	.165299	.8	.95320	897.85	.001114
.9	.82516	6.6859	.149569	.9	.99663	992.27	.001008
2.0	0.86859	7.3891	0.135335	**7.0**	3.04006	1096.6	0.000912
.1	.91202	8.1662	.122456	.1	.08349	1212.0	.000825
.2	.95545	9.0250	.110803	.2	.12692	1339.4	.000747
.3	.99888	9.9742	.100259	.3	.17035	1480.3	.000676
.4	1.04231	11.023	.090718	.4	.21378	1636.0	.000611
2.5	1.08574	12.182	0.082085	**7.5**	3.25721	1808.0	0.000553
.6	.12917	13.464	.074274	.6	.30064	1998.2	.000500
.7	.17260	14.880	.067206	.7	.34407	2208.3	.000453
.8	.21602	16.445	.060810	.8	.38750	2440.6	.000410
.9	.25945	18.174	.055023	.9	.43093	2697.3	.000371
3.0	1.30288	20.086	0.049787	**8.0**	3.47436	2981.0	0.000335
.1	.34631	22.198	.045049	.1	.51779	3294.5	.000304
.2	.38974	24.533	.040762	.2	.56121	3641.0	.000275
.3	.43317	27.113	.036883	.3	.60464	4023.9	.000249
.4	.47660	29.964	.033373	.4	.64807	4447.1	.000225
3.5	1.52003	33.115	0.030197	**8.5**	3.69150	4914.8	0.000203
.6	.56346	36.598	.027324	.6	.73493	5431.7	.000184
.7	.60689	40.447	.024724	.7	.77836	6002.9	.000167
.8	.65032	44.701	.022371	.8	.82179	6634.2	.000151
.9	.69375	49.402	.020242	.9	.86522	7332.0	.000136
4.0	1.73718	54.598	0.018316	**9.0**	3.90865	8103.1	0.000123
.1	.78061	60.340	.016573	.1	.95208	8955.3	.000112
.2	.82404	66.686	.014996	.2	.99551	9897.1	.000101
.3	.86747	73.700	.013569	.3	4.03894	10938.	.000091
.4	.91090	81.451	.012277	.4	.08237	12088.	.000083
4.5	1.95433	90.017	0.011109	**9.5**	4.12580	13360.	0.000075
.6	.99775	99.484	.010052	.6	.16923	14765.	.000068
.7	2.04118	109.95	.009095	.7	.21266	16318.	.000061
.8	.08461	121.51	.008230	.8	.25609	18034.	.000055
.9	.12804	134.29	.007447	.9	.29952	19930.	.000050
5.0	2.17147	148.41	0.006738	**10.0**	4.34294	22026.	0.000045

Taken from Glaisher's 'Tables of the Exponential Function,' Trans. Cambridge Phil. Soc. vol. xiii. 1883. This volume also contains a 'Table of the Descending Exponential to Twelve or Fourteen Places of Decimals,' by F. W. Newman.

TABLE 18.

EXPONENTIAL FUNCTIONS, LOG e^x.

x	$\log_{10}(e^x)$	x	$\log_{10}(e^x)$	x	$\log_{10}(e^x)$	x	$\log_{10}(e^x)$
10.0	4.34294	15.0	6.51442	20.0	8.68589	25.0	10.85736
.1	.38637	.1	.55785	.1	.72932	.1	.90079
.2	.42980	.2	.60128	.2	.77275	.2	.94422
.3	.47323	.3	.64471	.3	.81618	.3	.98765
.4	.51666	.4	.68814	.4	.85961	.4	11.03108
10.5	4.56009	15.5	6.73156	20.5	8.90304	25.5	11.07451
.6	.60352	.6	.77499	.6	.94647	.6	.11794
.7	.64695	.7	.81842	.7	.98990	.7	.16137
.8	.69038	.8	.86185	.8	9.03333	.8	.20480
.9	.73381	.9	.90528	.9	.07675	.9	.24823
11.0	4.77724	16.0	6.94871	21.0	9.12018	26.0	11.29166
.1	.82067	.1	.99214	.1	.16361	.1	.33509
.2	.86410	.2	7.03557	.2	.20704	.2	.37852
.3	.90753	.3	.07900	.3	.25047	.3	.42194
.4	.95096	.4	.12243	.4	.29390	.4	.46537
11.5	4.99439	16.5	7.16586	21.5	9.33733	26.5	11.50880
.6	5.03782	.6	.20929	.6	.38076	.6	.55223
.7	.08125	.7	.25272	.7	.42419	.7	.59566
.8	.12467	.8	.29615	.8	.46762	.8	.63909
.9	.16810	.9	.33958	.9	.51105	.9	.68252
12.0	5.21153	17.0	7.38301	22.0	9.55448	27.0	11.72595
.1	.25496	.1	.42644	.1	.59791	.1	.76938
.2	.29839	.2	.46987	.2	.64134	.2	.81281
.3	.34182	.3	.51329	.3	.68477	.3	.85624
.4	.38525	.4	.55672	.4	.72820	.4	.89967
12.5	5.42868	17.5	7.60015	22.5	9.77163	27.5	11.94310
.6	.47211	.6	.64358	.6	.81506	.6	.98653
.7	.51554	.7	.68701	.7	.85848	.7	12.02996
.8	.55897	.8	.73044	.8	.90191	.8	.07339
.9	.60240	.9	.77387	.9	.94534	.9	.11682
13.0	5.64583	18.0	7.81730	23.0	9.98877	28.0	12.16025
.1	.68926	.1	.86073	.1	10.03220	.1	.20367
.2	.73269	.2	.90416	.2	.07563	.2	.24710
.3	.77612	.3	.94759	.3	.11906	.3	.29053
.4	.81955	.4	.99102	.4	.16249	.4	.33396
13.5	5.86298	18.5	8.03445	23.5	10.20592	28.5	12.37739
.6	.90640	.6	.07788	.6	.24935	.6	.42082
.7	.94983	.7	.12131	.7	.29278	.7	.46425
.8	5.99326	.8	.16474	.8	.33621	.8	.50768
.9	6.03669	.9	.20817	.9	.37964	.9	.55111
14.0	6.08012	19.0	8.25160	24.0	10.42307	29.0	12.59454
.1	.12355	.1	.29502	.1	.46650	.1	.63797
.2	.16698	.2	.33845	.2	.50993	.2	.68140
.3	.21041	.3	.38188	.3	.55336	.3	.72483
.4	.25384	.4	.42531	.4	.59679	.4	.76826
14.5	6.29727	19.5	8.46874	24.5	10.64021	29.5	12.81169
.6	.34070	.6	.51217	.6	.68364	.6	.85512
.7	.38413	.7	.55560	.7	.72707	.7	.89855
.8	.42756	.8	.59903	.8	.77050	.8	.94198
.9	.47099	.9	.64246	.9	.81393	.9	.98541
15.0	6.51442	20.0	8.68589	25.0	10.85736	30.0	13.02883

TABLE 19.

EXPONENTIAL FUNCTIONS.

Value of e^{x^2} and e^{-x^2} and their logarithms.

The equation to the probability curve is $y = e^{-x^2}$, where x may have any value, positive or negative, between zero and infinity.

x	e^{x^2}	log e^{x^2}	e^{-x^2}	log e^{-x^2}
0.1	1.0101	0.00434	0.99005	$\bar{1}.99566$
2	1.0408	01737	96079	98263
3	1.0904	03909	91393	96091
4	1.1735	06949	85214	93051
5	1.2840	10857	77880	89143
0.6	1.4333	0.15635	0.69768	$\bar{1}.84365$
7	1.6323	21280	61263	78720
8	1.8965	27795	52729	72205
9	2.2479	35178	44486	64822
1.0	2.7183	43429	36788	56571
1.1	3.3535	0.52550	0.29820	$\bar{1}.47450$
2	4.2207	62538	23693	37462
3	5.4195	73396	18452	26604
4	7.0993	85122	14086	14878
5	9.4877	97716	10540	02284
1.6	1.2936×10	1.11179	0.77306×10^{-1}	$\bar{2}.88821$
7	1.7993 “	25511	55576 “	74489
8	2.5534 “	40711	39164 “	59289
9	3.6996 “	56780	27052 “	43220
2.0	5.4598 “	73718	18316 “	26282
2.1	8.2269 “	1.91524	0.12155 “	$\bar{2}.08476$
2	1.2647×10^2	2.10199	79070×10^{-2}	$\bar{3}.89801$
3	1.9834 “	29742	50418 “	70258
4	3.1735 “	50154	31511 “	49846
5	5.1802 “	71434	19304 “	28566
2.6	8.6264 “	2.93583	0.11592 “	$\bar{3}.06417$
7	1.4656×10^8	3.16601	68233×10^{-8}	$\bar{4}.83400$
8	2.5402 “	40487	39367 “	59513
9	4.4918 “	65242	22263 “	34758
3.0	8.1031 “	90865	12341 “	09135
3.1	1.4913×10^4	4.17357	0.67055×10^{-4}	$\bar{5}.82643$
2	2.8001 “	44718	35713 “	55283
3	5.3638 “	72947	18644 “	27053
4	1.0482×10^5	5.02044	95402×10^{-5}	$\bar{6}.97956$
5	2.0898 “	32011	47851 “	67989
3.6	4.2507 “	5.62846	0.23526 “	$\bar{6}.37154$
7	8.8205 “	94549	11337 “	05451
8	1.8673×10^6	6.27121	53554×10^{-6}	$\bar{7}.72879$
9	4.0329 “	60562	24796 “	39438
4.0	8.8861 “	94871	11254 “	05129
4.1	1.9976×10^7	7.30049	0.50062×10^{-7}	$\bar{8}.69951$
2	4.5809 “	66095	21829 “	33905
3	1.0718×10^8	8.03011	93303×10^{-8}	$\bar{9}.96989$
4	2.5583 “	40796	39088 “	59204
5	6.2297 “	79447	16052 “	20553
4.6	1.5476×10^9	9.18967	0.64614×10^{-9}	$\overline{10}.81033$
7	3.9228 “	59357	25494 “	40643
8	1.0143×10^{10}	10.00615	98595×10^{-10}	$\overline{11}.99385$
9	2.6755 “	42741	37376 “	57259
5.0	7.2005 “	85736	13888 “	14264

TABLE 20.

EXPONENTIAL FUNCTIONS.

Values of $e^{\frac{\pi}{4}x}$ and $e^{-\frac{\pi}{4}x}$ and their logarithms.

x	$e^{\frac{\pi}{4}x}$	$\log e^{\frac{\pi}{4}x}$	$e^{-\frac{\pi}{4}x}$	$\log e^{-\frac{\pi}{4}x}$
1	2.1933	0.34109	0.45594	$\bar{1}$.65891
2	4.8105	.68219	.20788	.31781
3	1.0551 $\times$ 10	1.02328	.94780 $\times 10^{-1}$	$\bar{2}$.97672
4	2.3141 "	.36438	.43214 "	.63562
5	5.0754 "	.70547	.19703 "	.29453
6	1.1132 $\times 10^2$	2.04656	0.89833 $\times 10^{-2}$	$\bar{3}$.95344
7	2.4415 "	.38766	.40958 "	.61234
8	5.3549 "	.72875	.18674 "	.27125
9	1.1745 $\times 10^3$	3.06985	.85144 $\times 10^{-3}$	$\bar{4}$.93015
10	2.5760 "	.41094	.38820 "	.58906
11	5.6498 "	3.75204	0.17700 "	$\bar{4}$.24796
12	1.2392 $\times 10^4$	4.09313	.80699 $\times 10^{-4}$	$\bar{5}$.90687
13	2.7168 "	.43422	.36794 "	.56578
14	5.9610 "	.77532	.16776 "	.22468
15	1.3074 $\times 10^5$	5.11641	.76487 $\times 10^{-5}$	$\bar{6}$.88359
16	2.8675 "	5.45751	0.34873 "	$\bar{6}$.54249
17	6.2893 "	.79860	.15900 "	.20140
18	1.3794 $\times 10^6$	6.13969	.72495 $\times 10^{-6}$	$\bar{7}$.86031
19	3.0254 "	.48079	.33053 "	.51921
20	6.6356 "	.82189	.15070 "	.17812

TABLE 21.

EXPONENTIAL FUNCTIONS.

Values of $e^{\frac{\sqrt{\pi}}{4}x}$ and $e^{-\frac{\sqrt{\pi}}{4}x}$ and their logarithms.

x	$e^{\frac{\sqrt{\pi}}{4}x}$	$\log e^{\frac{\sqrt{\pi}}{4}x}$	$e^{-\frac{\sqrt{\pi}}{4}x}$	$\log e^{-\frac{\sqrt{\pi}}{4}x}$
1	1.5576	0.19244	0.64203	$\bar{1}$.80756
2	2.4260	.38488	.41221	.61512
3	3.7786	.57733	.26465	.42267
4	5.8853	.76977	.16992	.23023
5	9.1666	.96221	.10909	.03779
6	14.277	1.15465	0.070041	$\bar{2}$.84535
7	22.238	.34709	.044968	.65291
8	34.636	.53953	.028871	.46047
9	53.948	.73198	.018536	.26802
10	84.027	.92442	.011901	.07558
11	130.87	2.11686	0.0076408	$\bar{3}$.88314
12	203.85	.30930	.0049057	.69070
13	317.50	.50174	.0031496	.49826
14	494.52	.69418	.0020222	.30582
15	770.24	.88663	.0012983	.11337
16	1199.7	3.07907	0.00083355	$\bar{4}$.92093
17	1868.5	.27151	.00053517	.72849
18	2910.4	.46395	.00034360	.53605
19	4533.1	.65639	.00022060	.34361
20	7060.5	.84883	.00014163	.15117

TABLE 22. — Exponential Functions.

Value of e^x and e^{-x} and their logarithms.

x	e^x	log e^x	e^{-x}	x	e^x	log e^x	e^{-x}
1/64	1.0157	0.00679	0.98450	1/3	1.3956	0.14476	0.71653
1/32	.0317	.01357	.96923	1/2	.6487	.21715	.60653
1/16	.0645	.02714	.93941	3/4	2.1170	.32572	.47237
1/10	.1052	.04343	.90484	1	.7183	.43429	.36788
1/9	.1175	.04825	.89484	5/4	3.4903	.54287	.28650
1/8	1.1331	0.05429	0.88250	3/2	4.4817	0.65144	0.22313
1/7	.1536	.06204	.86688	7/4	5.7546	.76002	.17377
1/6	.1814	.07238	.84648	2	7.3891	.86859	.13535
1/5	.2214	.08686	.81873	9/4	9.4877	.97716	.10540
1/4	.2840	.10857	.77880	5/2	12.1825	1.08574	.08208

TABLE 23. — Least Squares.

Values of $P = \frac{2}{\sqrt{\pi}}\int_0^{hx} e^{-(hx)^2}\, d(hx)$.

This table gives the value of P, the probability of an observational error having a value positive or negative equal to or less than x when h is the measure of precision, $P = \frac{2}{\sqrt{\pi}}\int_0^{hx} e^{-(hx)^2}\, d(hx)$. For values of the inverse function see the table on Diffusion.

hx	1	2	3	4	5	6	7	8	9	10
0.0	.01128	.02256	.03384	.04511	.05637	.06762	.07886	.09008	.10128	.11246
.1	.12362	.13476	.14587	.15695	.16800	.17901	.18999	.20094	.21184	.22270
.2	.23352	.24430	.25502	.26570	.27633	.28690	.29742	.30788	.31828	.32863
.3	.33891	.34913	.35928	.36936	.37938	.38933	.39921	.40901	.41874	.42839
.4	.43797	.44747	.45689	.46623	.47548	.48466	.49375	.50275	.51167	.52050
0.5	.52924	.53790	.54646	.55494	.56332	.57162	.57982	.58792	.59594	.60386
.6	.61168	.61941	.62705	.63459	.64203	.64938	.65663	.66378	.67084	.67780
.7	.68467	.69143	.69810	.70468	.71116	.71754	.72382	.73001	.73610	.74210
.8	.74800	.75381	.75952	.76514	.77067	.77610	.78144	.78669	.79184	.79691
.9	.80188	.80677	.81156	.81627	.82089	.82542	.82987	.83423	.83851	.84270
1.0	.84681	.85084	.85478	.85865	.86244	.86614	.86977	.87333	.87680	.88021
.1	.88353	.88679	.88997	.89308	.89612	.89910	.90200	.90484	.90761	.91031
.2	.91296	.91553	.91805	.92051	.92290	.92524	.92751	.92973	.93190	.93401
.3	.93606	.93807	.94002	.94191	.94376	.94556	.94731	.94902	.95067	.95229
.4	.95385	.95538	.95686	.95830	.95970	.96105	.96237	.96365	.96490	.96611
1.5	.96728	.96841	.96952	.97059	.97162	.97263	.97360	.97455	.97546	.97635
.6	.97721	.97804	.97884	.97962	.98038	.98110	.98181	.98249	.98315	.98379
.7	.98441	.98500	.98558	.98613	.98667	.98719	.98769	.98817	.98864	.98909
.8	.98952	.98994	.99035	.99074	.99111	.99147	.99182	.99216	.99248	.99279
.9	.99309	.99338	.99366	.99392	.99418	.99443	.99466	.99489	.99511	.99532
2.0	.99552	.99572	.99591	.99609	.99626	.99642	.99658	.99673	.99688	.99702
.1	.99715	.99728	.99741	.99753	.99764	.99775	.99785	.99795	.99805	.99814
.2	.99822	.99831	.99839	.99846	.99854	.99861	.99867	.99874	.99880	.99886
.3	.99891	.99897	.99902	.99906	.99911	.99915	.99920	.99924	.99928	.99931
.4	.99935	.99938	.99941	.99944	.99947	.99950	.99952	.99955	.99957	.99959
2.5	.99961	.99963	.99965	.99967	.99969	.99971	.99972	.99974	.99975	.99976
.6	.99978	.99979	.99980	.99981	.99982	.99983	.99984	.99985	.99986	.99987
.7	.99987	.99988	.99989	.99989	.99990	.99991	.99991	.99992	.99992	.99992
.8	.99993	.99993	.99994	.99994	.99994	.99995	.99995	.99995	.99996	.99996
.9	.99996	.99996	.99997	.99997	.99997	.99997	.99997	.99997	.99998	.99998
3.0	.99999	.99999	1.00000							

Taken from a paper by Dr. James Burgess 'on the Definite Integral $\frac{2}{\sqrt{\pi}}\int_0^{t} e^{-t^2}\, dt$, with Extended Tables of Values.' Trans. Roy. Soc. of Edinburgh, vol. xxxix, 1900, p. 257.

TABLE 24.

LEAST SQUARES.

This table gives the values of the probability P, as defined in last table, corresponding to different values of x/r where r is the "probable error." The probable error r is equal to $0.47694/h$.

$\frac{x}{r}$	0	1	2	3	4	5	6	7	8	9
0.0	.00000	.00538	.01076	.01614	.02152	.02690	.03228	.03766	.04303	.04840
0.1	.05378	.05914	.06451	.06987	.07523	.08059	.08594	.09129	.09663	.10197
0.2	.10731	.11264	.11796	.12328	.12860	13391	.13921	.14451	.14980	.15508
0.3	.16035	.16562	.17088	.17614	.18138	.18662	.19185	.19707	.20229	.20749
0.4	.21268	.21787	.22304	.22821	.23336	.23851	.24364	.24876	.25388	.25898
0.5	.26407	.26915	.27421	.27927	.28431	.28934	.29436	.29936	.30435	.30933
0.6	.31430	.31925	.32419	.32911	.33402	.33892	.34380	.34866	.35352	.35835
0.7	.36317	.36798	.37277	.37755	.38231	.38705	.39178	.39649	.40118	.40586
0.8	.41052	.41517	.41979	.42440	.42899	.43357	.43813	.44267	.44719	.45169
0.9	.45618	.46064	.46509	.46952	.47393	.47832	.48270	48605	.49139	.49570
1.0	.50000	.50428	.50853	.51277	.51699	.52119	.52537	.52952	.53366	.53778
1.1	.54188	.54595	.55001	.55404	.55806	.56205	.56602	.56998	.57391	.57782
1.2	.58171	.58558	.58942	.59325	.59705	.60083	.60460	.60833	.61205	.61575
1.3	.61942	.62308	.62671	.63032	.63391	.63747	.64102	.64554	.64804	.65152
1.4	.65498	.65841	.66182	.66521	.66858	.67193	.67526	.67856	.68184	.68510
1.5	.68833	.69155	.69474	.69791	.70106	.70419	.70729	.71038	.71344	.71648
1.6	.71949	.72249	.72546	.72841	.73134	.73425	.73714	.74000	.74285	.74567
1.7	.74847	.75124	.75400	.75674	.75945	.76214	.76481	.76746	.77009	.77270
1.8	.77528	.77785	.78039	.78291	.78542	.78790	.79036	.79280	.79522	.79761
1.9	.79999	.80235	.80469	.80700	.80930	.81158	.81383	.81607	.81828	.82048
2.0	.82266	.82481	.82695	.82907	.83117	.83324	.83530	.83734	.83936	.84137
2.1	.84335	.84531	.84726	.84919	.85109	.85298	.85486	.85671	.85854	.86036
2.2	.86216	.86394	.86570	.86745	.86917	.87088	.87258	.87425	.87591	.87755
2.3	.87918	.88078	.88237	.88395	.88550	.88705	.88857	.89008	.89157	.89304
2.4	.89450	.89595	.89738	.89879	.90019	.90157	.90293	.90428	.90562	.90694
2.5	.90825	.90954	.91082	.91208	.91332	.91456	.91578	.91698	.91817	.91935
2.6	.92051	.92166	.92280	.92392	.92503	.92613	.92721	.92828	.92934	.93038
2.7	.93141	.93243	.93344	.93443	.93541	.93638	.93734	.93828	.93922	.94014
2.8	.94105	.94195	.94284	.94371	.94458	.94543	.94627	.94711	.94793	.94874
2.9	.94954	.95033	.95111	.95187	.95263	.95338	.95412	.95484	.95557	.95628
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
3	.95698	.96346	.96910	.97397	.97817	.98176	.98482	.98743	.98962	.99147
4	.99302	.99431	.99539	99627	.99700	.99760	.99808	.99848	.99879	.99905
5	.99926	.99943	.99956	.99966	.99974	.99980	.99985	.99988	.99991	.99993

TABLE 25.

LEAST SQUARES.

Values of the factor $0.6745\sqrt{\frac{1}{n-1}}$.

This factor occurs in the equation $e_s = 0.6745\sqrt{\frac{\Sigma y^2}{n-1}}$ for the probable error of a single observation, and other similar equations.

n	=	1	2	3	4	5	6	7	8	9
00			0.6745	0.4769	0.3894	0.3372	0.3016	0.2754	0.2549	0.2385
10	0.2248	0.2133	.2029	.1947	.1871	.1803	.1742	.1686	.1636	.1590
20	.1547	.1508	.1472	.1438	.1406	.1377	.1349	.1323	.1298	.1275
30	.1252	.1231	.1211	.1192	.1174	.1157	.1140	.1124	.1109	.1094
40	.1080	.1066	.1053	.1041	.1029	.1017	.1005	.0994	.0984	.0974
50	0.0964	0.0954	0.0944	0.0935	0.0926	0.0918	0.0909	0.0901	0.0893	0.0886
60	.0878	.0871	.0864	.0857	.0850	.0843	.0837	.0830	.0824	.0818
70	.0812	.0806	.0800	.0795	.0789	.0784	.0778	.0773	.0768	.0763
80	.0759	.0754	.0749	.0745	.0740	.0736	.0731	.0727	.0723	.0719
90	.0715	.0711	.0707	.0703	.0699	.0696	.0692	.0688	.0685	.0681

TABLE 26.

LEAST SQUARES.

Values of the factor $0.6745\sqrt{\frac{1}{n(n-1)}}$.

This factor occurs in the equation $e_m = 0.6745\sqrt{\frac{\Sigma y^2}{n(n-1)}}$ for the probable error of the arithmetic mean.

n	=	1	2	3	4	5	6	7	8	9
00			0.4769	0.2754	0.1947	0.1508	0.1231	0.1041	0.0901	0.0795
10	0.0711	0.0643	.0587	.0540	.0500	.0465	.0435	.0409	.0386	.0365
20	.0346	.0329	.0314	.0300	.0287	.0275	.0265	.0255	.0245	.0237
30	0.0229	0.0221	0.0214	0.0208	0.0201	0.0196	0.0190	0.0185	0.0180	0.0175
40	.0171	.0167	.0163	.0159	.0155	.0152	.0148	.0145	.0142	.0139
50	.0136	.0134	.0131	.0128	.0126	.0124	.0122	.0119	.0117	.0115

TABLE 27.

LEAST SQUARES.

Values of the factor $0.8453\sqrt{\frac{1}{n(n-1)}}$.

This factor occurs in the equation $e_s = 0.8453\frac{\Sigma y}{\sqrt{n(n-1)}}$ for the probable error of a single observation.

n	=	1	2	3	4	5	6	7	8	9
00			0.5978	0.3451	0.2440	0.1890	0.1543	0.1304	0.1130	0.0996
10	0.0891	0.0806	.0736	.0677	.0627	.0583	.0546	.0513	.0483	.0457
20	.0434	.0412	.0393	.0376	.0360	.0345	.0332	.0319	.0307	.0297
30	0.0287	0.0277	0.0268	0.0260	0.0252	0.0245	0.0238	0.0232	0.0225	0.0220
40	.0214	.0209	.0204	.0199	.0194	.0190	.0186	.0182	.0178	.0174
50	.0171	.0167	.0164	.0161	.0158	.0155	.0152	.0150	.0147	.0145

TABLE 28.

LEAST SQUARES.

Values of $0.8453\frac{1}{n\sqrt{n-1}}$.

This table gives the average error of the arithmetic mean when the probable error is one.

n	=	1	2	3	4	5	6	7	8	9
00			0.4227	0.1993	0.1220	0.0845	0.0630	0.0493	0.0399	0.0332
10	0.0282	0.0243	.0212	.0188	.0167	.0151	.0136	.0124	.0114	.0105
20	.0097	.0090	.0084	.0078	.0073	.0069	.0065	.0061	.0058	.0055
30	0.0052	0.0050	0.0047	0.0045	0.0043	0.0041	0.0040	0.0038	0.0037	0.0035
40	.0034	.0033	.0031	.0030	.0029	.0028	.0027	.0027	.0026	.0025
50	.0024	.0023	.0023	.0022	.0022	.0021	.0020	.0020	.0019	.0019

Table 29.

DIFFUSION.

Inverse* values of $v/c = 1 - \frac{2}{\sqrt{\pi}} \int_0^q \varepsilon^{-q^2} dq.$

$\log x = \log (2q) + \log \sqrt{kt}$. t expressed in seconds.
$= \log \delta + \log \sqrt{kt}$. t expressed in days.
$= \log \gamma + \log \sqrt{kt}$. " " years.
k = coefficient of diffusion.†
c = initial concentration.
v = concentration at distance x, time t.

v/c	$\log 2q$	$2q$	$\log \delta$	δ	$\log \gamma$	γ
0.00	+∞	+∞	+∞	+∞	∞	∞
.01	0.56143	3.6428	3.02970	1070.78	4.31098	20463.
.02	.51719	3.2900	2.98545	967.04	.26674	18481.
.03	.48699	3.0690	.95525	902.90	.23654	17240.
.04	.46306	2.9044	.93132	853.73	.21261	16316.
0.05	0.44276	2.7718	2.91102	814.74	4.19231	15571.
.06	.42486	2.6598	.89311	781.83	.17440	14942.
.07	.40865	2.5624	.87691	753.20	.15820	14395.
.08	.39372	2.4758	.86198	727.75	.14327	13908.
.09	.37979	2.3977	.84804	704.76	.12933	13469.
0.10	0.36664	2.3262	2.83490	683.75	4.11619	13067.
.11	.35414	2.2602	.82240	664.36	.10369	12697.
.12	.34218	2.1988	.81044	646.31	.09173	12352.
.13	.33067	2.1413	.79893	629.40	.08022	12029.
.14	.31954	2.0871	.78780	613.47	.06909	11724.
0.15	0.30874	2.0358	2.77699	598.40	4.05828	11436.
.16	.29821	1.9871	.76647	584.08	.04776	11162.
.17	.28793	1.9406	.75619	570.41	.03748	10901.
.18	.27786	1.8961	.74612	557.34	.02741	10652.
.19	.26798	1.8534	.73624	544.80	.01753	10412.
0.20	0.25825	1.8124	2.72651	532.73	4.00780	10181.
.21	.24866	1.7728	.71692	521.10	3.99821	9958.9
.22	.23919	1.7346	.70745	509.86	.98874	9744.1
.23	.22983	1.6976	.69808	498.98	.97937	9536.2
.24	.22055	1.6617	.68880	488.43	.97010	9334.6
0.25	0.21134	1.6268	2.67960	478.19	3.96089	9138.9
.26	.20220	1.5930	.67046	468.23	.95175	8948.5
.27	.19312	1.5600	.66137	458.53	.94266	8763.2
.28	.18407	1.5278	.65232	449.08	.93361	8582.5
.29	.17505	1.4964	.64331	439.85	.92460	8406.2
0.30	0.16606	1.4657	2.63431	430.84	3.91560	8233.9
.31	.15708	1.4357	.62533	422.02	.90662	8065.4
.32	.14810	1.4064	.61636	413.39	.89765	7900.4
.33	.13912	1.3776	.60738	404.93	.88867	7738.8
.34	.13014	1.3494	.59840	396.64	.87969	7580.3
0.35	0.12114	1.3217	2.58939	388.50	3.87068	7424.8
.36	.11211	1.2945	.58037	380.51	.86166	7272.0
.37	.10305	1.2678	.57131	372.66	.85260	7122.0
.38	.09396	1.2415	.56222	364.93	.84351	6974.4
.39	.08482	1.2157	.55308	357.34	.83437	6829.2
0.40	0.07563	1.1902	2.54389	349.86	3.82518	6686.2
.41	.06639	1.1652	.53464	342.49	.81593	6545.4
.42	.05708	1.1405	.52533	335.22	.80662	6406.6
.43	.04770	1.1161	.51595	328.06	.79724	6269.7
.44	.03824	1.0920	.50650	320.99	.78779	6134.6
0.45	0.02870	1.0683	2.49696	314.02	3.77825	6001.3
.46	.01907	1.0449	.48733	307.13	.76862	5869.7
.47	.00934	1.0217	.47760	300.33	.75889	5739.7
.48	9.99951	0.99886	.46776	293.60	.74905	5611.2
.49	.98956	0.97624	.45782	286.96	.73911	5484.1
0.50	9.97949	0.95387	2.44775	280.38	3.72904	5358.4

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* Kelvin, Mathematical and Physical Papers, vol. III. p. 428 ; Becker, Am. Jour. of Sci. vol. III. 1897, p. 280.

† For direct values see table 23.

Taken from unpublished manuscript of C. E. Van Orstrand.

TABLE 29 (*continued*).

DIFFUSION.

v/*c*	log 2*q*	2*q*	log δ	δ	log γ	γ
0.50	9.97949	0.95387	2.44775	280.38	3.72904	5358.4
.51	.96929	.93174	.43755	273.87	.71884	5234.1
.52	.95896	.90983	.42722	267.43	.70851	5111.0
.53	.94848	.88813	.41674	261.06	.69803	4989.1
.54	.93784	.86665	.40610	254.74	.68739	4868.4
0.55	9.92704	0.84536	2.39530	248.48	3.67659	4748.9
.56	.91607	.82426	.38432	242.28	.66561	4630.3
.57	.90490	.80335	.37316	236.13	.65445	4512.8
.58	.89354	.78260	.36180	230.04	.64309	4396.3
.59	.88197	.76203	.35023	223.99	.63152	4280.7
0.60	9.87018	0.74161	2.33843	217.99	3.61973	4166.1
.61	.85815	.72135	.32640	212.03	.60770	4052.2
.62	.84587	.70124	.31412	206.12	.59541	3939.2
.63	.83332	.68126	.30157	200.25	.58286	3827.0
.64	.82048	.66143	.28874	194.42	.57003	3715.6
0.65	9.80734	0.64172	2.27560	188.63	3.55689	3604.9
.66	.79388	.62213	.26214	182.87	.54343	3494.9
.67	.78008	.60266	.24833	177.15	.52962	3385.4
.68	.76590	.58331	.23416	171.46	.51545	3276.8
.69	.75133	.56407	.21959	165.80	.50088	3168.7
0.70	9.73634	0.54493	2.20459	160.17	3.48588	3061.1
.71	.72089	.52588	.18915	154.58	.47044	2954.2
.72	.70495	.50694	.17321	149.01	.45450	2847.7
.73	.68849	.48808	.15675	143.47	.43804	2741.8
.74	.67146	.46931	.13972	137.95	.42101	2636.4
0.75	9.65381	0.45062	2.12207	132.46	3.40336	2531.4
.76	.63550	.43202	.10376	126.99	.38505	2426.9
.77	.61646	.41348	.08471	121.54	.36600	2322.7
.78	.59662	.39502	.06487	116.11	.34616	2219.0
.79	.57590	.37662	.04416	110.70	.32545	2115.7
0.80	9.55423	0.35829	2.02249	105.31	3.30378	2012.7
.81	.53150	.34001	1.99975	99.943	.28104	1910.0
.82	.50758	.32180	.97584	94.589	.25713	1807.7
.83	.48235	.30363	.95061	89.250	.23190	1705.7
.84	.45564	.28552	.92389	83.926	.20518	1603.9
0.85	9.42725	0.26745	1.89551	78.615	3.17680	1502.4
.86	.39695	.24943	.86521	73.317	.14650	1401.2
.87	.36445	.23145	.83271	68.032	.11400	1300.2
.88	.32940	.21350	.79766	62.757	.07895	1199.4
.89	.29135	.19559	.75961	57.492	3.04090	1098.7
0.90	9.24972	0.17771	1.71797	52.236	2.99926	998.31
.91	.20374	.15986	.67200	46.989	.95329	898.03
.92	.15239	.14203	.62065	41.750	.90194	797.89
.93	.09423	.12423	.56249	36.516	.84378	697.88
.94	9.02714	.10645	.49539	31.289	.77668	597.98
0.95	8.94783	0.08868	1.41609	26.067	2.69738	498.17
.96	.85082	.07093	.31907	20.848	.60036	398.44
.97	.72580	.05319	.19406	15.633	.47535	298.78
.98	.54965	.03545	.01791	10.421	.29920	199.16
.99	.24859	.01773	9.71684	5.21007	1.99813	99.571
1.00	−∞	0.00000	−∞	0.00000	−∞	0.000

TABLE 30.

GAMMA FUNCTION.*

$$\text{Value of } \log \int_0^\infty e^{-x} x^{n-1} dx + 10.$$

Values of the logarithms + 10 of the "Second Eulerian Integral" (Gamma function) $\int_0^\infty e^{-x} x^{n-1} dx$ or $\log \Gamma(n) + 10$ for values of n between 1 and 2. When n has values not lying between 1 and 2 the value of the function can be readily calculated from the equation $\Gamma(n+1) = n\Gamma(n) = n(n-1) \ldots (n-r)\Gamma(n-r)$.

n	0	1	2	3	4	5	6	7	8	9
1.00	9.99———	97497	95001	92512	90030	87555	85087	82627	80173	77727
1.01	75287	72855	70430	68011	65600	63196	60799	58408	56025	53648
1.02	51279	48916	46561	44212	41870	39535	37207	34886	32572	30265
1.03	27964	25671	23384	21104	18831	16564	14305	12052	09806	07567
1.04	05334	03108	00889	98677	96471	94273	92080	89895	87716	85544
1.05	9.9883379	81220	79068	76922	74783	72651	70525	68406	66294	64188
1.06	62089	59996	57910	55830	53757	51690	49630	47577	45530	43489
1.07	41469	39428	37407	35392	33384	31382	29387	27398	25415	23449
1.08	21469	19506	17549	15599	13655	11717	09785	07860	05941	04029
1.09	02123	00223	98329	96442	94561	92686	90818	89856	87100	85250
1.10	9.9783407	81570	79738	77914	76095	74283	72476	70676	68882	67095
1.11	65313	63538	61768	60005	58248	56497	54753	53014	51281	49555
1.12	47834	46120	44411	42709	41013	39323	37638	35960	34288	32622
1.13	30962	29308	27659	26017	24381	22751	21126	19508	17896	16289
1.14	14689	13094	11505	09922	08345	06774	05209	03650	02096	00549
1.15	9.9699007	97471	95941	94417	92898	91386	89879	88378	86883	85393
1.16	83910	82432	80960	79493	78033	76578	75129	73686	72248	70816
1.17	69390	67969	66554	65145	63742	62344	60952	59566	58185	56810
1.18	55440	54076	52718	51366	50019	48677	47341	46011	44687	43368
1.19	42054	40746	39444	38147	36856	35570	34290	33016	31747	30483
1.20	9.9629225	27973	26725	25484	24248	23017	21792	20573	19358	18150
1.21	16946	15748	14556	13369	12188	11011	09841	08675	07515	06361
1.22	05212	04068	02930	01796	00669	99546	98430	97318	96212	95111
1.23	594015	92925	91840	90760	89685	88616	87553	86494	85441	84393
1.24	83350	82313	81280	80253	79232	78215	77204	76198	75197	74201
1.25	9.9573211	72226	71246	70271	69301	68337	67377	66423	65474	64530
1.26	63592	62658	61730	60806	59888	58975	58067	57165	56267	55374
1.27	54487	53604	52727	51855	50988	50126	49268	48416	47570	46728
1.28	45891	45059	44232	43410	42593	41782	40975	40173	39376	38585
1.29	37798	37016	36239	35467	34700	33938	33181	32439	31682	30940
1.30	9.9530203	29470	28743	28021	27303	26590	25883	25180	24482	23789
1.31	23100	22417	21739	21065	20396	19732	19073	18419	17770	17125
1.32	16485	15850	15220	14595	13975	13359	12748	12142	11540	10944
1.33	10353	09766	09184	08606	08034	07466	06903	06344	05791	05242
1.34	04698	04158	03624	03094	02568	02048	01532	01021	00514	00012
1.35	9.9499515	99023	98535	98052	97573	97100	96630	96166	95706	95251
1.36	94800	94355	93913	93477	93044	92617	92194	91776	91362	90953
1.37	90549	90149	89754	89363	88977	88595	88218	87846	87478	87115
1.38	86756	86402	86052	85707	85366	85030	84698	84371	84049	83731
1.39	83417	83108	82803	82503	82208	81916	81630	81348	81070	80797
1.40	9.9480528	80263	80003	79748	79497	79250	79008	78770	78537	78308
1.41	78084	77864	77648	77437	77230	77027	76829	76636	76446	76261
1.42	76081	75905	75733	75565	75402	75243	75089	74939	74793	74652
1.43	74515	74382	74254	74130	74010	73894	73783	73676	73574	73746
1.44	73382	73292	73207	73125	73049	72976	72908	72844	72784	72728

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* Quoted from Carr's "Synopsis of Mathematics," and is there quoted from Legendre's "Exercises de Calcul Intégral," tome ii.

TABLE 30 (*continued*).

GAMMA FUNCTION.

n	0	1	2	3	4	5	6	7	8	9
1.45	9.9472677	72630	72587	72549	72514	72484	72459	72437	72419	72406
1.46	72397	72393	72392	72396	72404	72416	72432	72452	72477	72506
1.47	72539	72576	72617	72662	72712	72766	72824	72886	72952	73022
1.48	73097	73175	73258	73345	73436	73531	73630	73734	73841	73953
1.49	74068	74188	74312	74440	74572	74708	74848	74992	75141	75293
1.50	9.9475449	75610	75774	75943	76116	76292	76473	76658	76847	77040
1.51	77237	77438	77642	77851	78064	78281	78502	78727	78956	79189
1.52	79426	79667	79912	80161	80414	80671	80932	81196	81465	81738
1.53	82015	82295	82580	82868	83161	83457	83758	84062	84370	84682
1.54	84998	85318	85642	85970	86302	86638	86977	87321	87668	88019
1.55	9.9488374	88733	89096	89463	89834	90208	90587	90969	91355	91745
1.56	92139	92537	92938	93344	93753	94166	94583	95004	95429	95857
1.57	96289	96725	97165	97609	98056	98508	98963	99422	99885	00351
1.58	500822	01296	01774	02255	02741	03230	03723	04220	04720	05225
1.59	05733	06245	06760	07280	07803	08330	08860	09395	09933	10475
1.60	9.9511020	11569	12122	12679	13240	13804	14372	14943	15519	16098
1.61	16680	17267	17857	18451	19048	19650	20254	20862	21475	22091
1.62	22710	23333	23960	24591	25225	25863	26504	27149	27798	28451
1.63	29107	29767	30430	31097	31767	32442	33120	33801	34486	35175
1.64	35867	36563	37263	37966	38673	39383	40097	40815	41536	42260
1.65	9.9542989	43721	44456	45195	45938	46684	47434	48187	48944	49704
1.66	50468	51236	52007	52782	53560	54342	55127	55916	56708	57504
1.67	58303	59106	59913	60723	61536	62353	63174	63998	64826	65656
1.68	66491	67329	68170	69015	69864	70716	71571	72430	73293	74159
1.69	75028	75901	76777	77657	78540	79427	80317	81211	82108	83008
1.70	9.9583912	84820	85731	86645	87536	88484	89409	90337	91268	92203
1.71	93141	94083	95028	95977	96929	97884	98843	99805	00771	01740
1.72	602712	03688	04667	05650	06636	07625	08618	09614	10613	11616
1.73	12622	13632	14645	15661	16681	17704	18730	19760	20793	21830
1.74	22869	23912	24959	26009	27062	28118	29178	30241	31308	32377
1.75	9.9633451	34527	35607	36690	37776	38866	39959	41055	42155	43258
1.76	44364	45473	46586	47702	48821	49944	51070	52200	53331	54467
1.77	55606	56749	57894	59043	60195	61350	62509	63671	64836	66004
1.78	67176	68351	69529	70710	71895	73082	74274	75468	76665	77866
1.79	79070	80277	81488	82701	83198	85138	86361	87588	88818	90051
1.80	9.9691287	92526	93768	95014	96263	97515	98770	00029	01291	02555
1.81	703823	05095	06369	07646	08927	10211	11498	12788	14082	15378
1.82	16678	17981	19287	20596	21908	23224	24542	25864	27189	28517
1.83	29848	31182	32520	33860	35204	36551	37900	39254	40610	41969
1.84	43331	44697	46065	47437	48812	50190	51571	52955	54342	55733
1.85	9.9757126	58522	59922	61325	62730	64140	65551	66966	68384	69805
1.86	71230	72657	74087	75521	76957	78397	79839	81285	82734	84186
1.87	85640	87098	88559	90023	91490	92960	94433	95910	97389	98871
1.88	800356	01844	03335	04830	06327	07827	09331	10837	12346	13859
1.89	15374	16893	18414	19939	21466	22996	24530	26066	27606	29148
1.90	9.9830693	32242	33793	35348	36905	38465	40028	41595	43164	44736
1.91	46311	47890	49471	51055	52642	54232	55825	57421	59020	60622
1.92	62226	63834	65445	67058	68675	70294	71917	73542	75170	76802
1.93	78436	80073	81713	83356	85002	86651	88302	89957	91614	93275
1.94	94938	96605	98274	99946	01621	03299	04980	06663	08350	10039
1.95	9.9911732	13427	15125	16826	18530	20237	21947	23659	25375	27093
1.96	28815	30539	32266	33995	35728	37464	39202	40943	42688	44435
1.97	46185	47937	49693	51451	53213	54977	56744	58513	60286	62062
1.98	63840	65621	67405	69192	70982	72774	74570	76368	78169	79972
1.99	81779	83588	85401	87216	89034	90854	92678	94504	96333	98165

TABLE 31.

ZONAL HARMONICS.*

The values of the first seven zonal harmonics are here given for every degree between $\theta = 0^\circ$ and $\theta = 90^\circ$.

θ	z_1	z_2	z_3	z_4	z_5	z_6	z_7
0°	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1°	0.9998	0.9995	0.9991	0.9985	0.9977	0.9967	0.9955
2	.9994	.9982	.9963	.9939	.9909	.9872	.9829
3	.9986	.9959	.9918	.9863	.9795	.9713	.9617
4	.9976	.9927	.9854	.9758	.9638	.9495	.9329
5	.9962	.9886	.9773	.9623	.9437	.9216	.8961
6°	.9945	.9836	.9674	.9459	.9194	.8881	.8522
7	.9925	.9777	.9557	.9267	.8911	.8476	.7986
8	.9903	.9709	.9423	.9048	.8589	.8053	.7448
9	.9877	.9633	.9273	.8803	.8232	.7571	.6831
10	.9848	.9548	.9106	.8532	.7840	.7045	.6164
11°	.9816	.9454	.8923	.8238	.7417	.6483	.5461
12	.9781	.9352	.8724	.7920	.6966	.5892	.4732
13	.9744	.9241	.8511	.7582	.6489	.5273	.3940
14	.9703	.9122	.8283	.7224	.5990	.4635	.3219
15	.9659	.8995	.8042	.6847	.5471	.3982	.2454
16°	.9613	.8860	.7787	.6454	.4937	.3322	.1699
17	.9563	.8718	.7519	.6046	.4391	.2660	.0961
18	.9511	.8568	.7240	.5624	.3836	.2002	.0289
19	.9455	.8410	.6950	.5192	.3276	.1347	—.0443
20	.9397	.8245	.6649	.4750	.2715	.0719	—.1072
21°	.9336	.8074	.6338	.4300	.2156	.0107	—.1662
22	.9272	.7895	.6019	.3845	.1602	—.0481	—.2201
23	.9205	.7710	.5692	.3386	.1057	—.1038	—.2681
24	.9135	.7518	.5357	.2926	.0525	—.1559	—.3095
25	.9063	.7321	.5016	.2465	.0009	—.2053	—.3463
26°	.8988	.7117	.4670	.2007	—.0489	—.2478	—.3717
27	.8910	.6908	.4319	.1553	—.0964	—.2869	—.3921
28	.8829	.6694	.3964	.1105	—.1415	—.3211	—.4052
29	.8746	.6474	.3607	.0665	—.1839	—.3503	—.4114
30	.8660	.6250	.3248	.0234	—.2233	—.3740	—.4101
31°	.8572	.6021	.2887	—.0185	—.2595	—.3924	—.4022
32	.8480	.5788	.2527	—.0591	—.2923	—.4052	—.3876
33	.8387	.5551	.2167	—.0982	—.3216	—.4126	—.3670
34	.8290	.5310	.1809	—.1357	—.3473	—.4148	—.3409
35	.8192	.5065	.1454	—.1714	—.3691	—.4115	—.3096
36°	.8090	.4818	.1102	—.2052	—.3871	—.4031	—.2738
37	.7986	.4567	.0755	—.2370	—.4011	—.3898	—.2343
38	.7880	.4314	.0413	—.2666	—.4112	—.3719	—.1918
39	.7771	.4059	.0077	—.2940	—.4174	—.3497	—.1469
40	.7660	.3802	—.0252	—.3190	—.4197	—.3234	—.1003
41°	.7547	.3544	—.0574	—.3416	—.4181	—.2938	—.0534
42	.7431	.3284	—.0887	—.3616	—.4128	—.2611	—.0065
43	.7314	.3023	—.1191	—.3791	—.4038	—.2255	.0395
44	.7193	.2762	—.1485	—.3940	—.3914	—.1878	.0846
45	.7071	.2500	—.1768	—.4062	—.3757	—.1485	.1270

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* Calculated by Prof. Perry (Phil. Mag. Dec. 1891). See also A. Gray, "Absolute Measurements in Electricity and Magnetism," vol. ii., part 2.

TABLE 31 (*continued*).

ZONAL HARMONICS.

θ	z_1	z_2	z_3	z_4	z_5	z_6	z_7
46°	0.6947	0.2238	—.2040	—.4158	—.3568	—.1079	0.1666
47	.6820	.1977	—.2300	—.4252	—.3350	—.0645	.2054
48	.6691	.1716	—.2547	—.4270	—.3105	—.0251	.2349
49	.6561	.1456	—.2781	—.4286	—.2836	.0161	.2627
50	.6428	.1198	—.3002	—.4275	—.2545	.0563	.2854
51°	.6293	.0941	—.3209	—.4239	—.2235	.0954	.3031
52	.6157	.0686	—.3401	—.4178	—.1910	.1326	.3153
53	.6018	.0433	—.3578	—.4093	—.1571	.1677	.3221
54	.5878	.0182	—.3740	—.3984	—.1223	.2002	.3234
55	.5736	—.0065	—.3886	—.3852	—.0868	.2297	.3191
56°	.5592	—.0310	—.4016	—.3698	—.0510	.2559	.3095
57	.5446	—.0551	—.4131	—.3524	—.0150	.2787	.2949
58	.5299	—.0788	—.4229	—.3331	.0206	.2976	.2752
59	.5150	—.1021	—.4310	—.3119	.0557	.3125	.2511
60	.5000	—.1250	—.4375	—.2891	.0898	.3232	.2231
61°	.4848	—.1474	—.4423	—.2647	.1229	.3298	.1916
62	.4695	—.1694	—.4455	—.2390	.1545	.3321	.1571
63	.4540	—.1908	—.4471	—.2121	.1844	.3302	.1203
64	.4384	—.2117	—.4470	—.1841	.2123	.3240	.0818
65	.4226	—.2321	—.4452	—.1552	.2381	.3138	.0422
66°	.4067	—.2518	—.4419	—.1256	.2615	.2996	.0021
67	.3907	—.2710	—.4370	—.0955	.2824	.2819	—.0375
68	.3746	—.2896	—.4305	—.0650	.3005	.2605	—.0763
69	.3584	—.3074	—.4225	—.0344	.3158	.2361	—.1135
70	.3420	—.3245	—.4130	—.0038	.3281	.2089	—.1485
71°	.3256	—.3410	—.4021	.0267	.3373	.1786	—.1811
72	.3090	—.3568	—.3898	.0568	.3434	.1472	—.2099
73	.2924	—.3718	—.3761	.0864	.3463	.1144	—.2347
74	.2756	—.3860	—.3611	.1153	.3461	.0795	—.2559
75	.2588	—.3995	—.3449	.1434	.3427	.0431	—.2730
76°	.2419	—.4112	—.3275	.1705	.3362	.0076	—.2848
77	.2250	—.4241	—.3090	.1964	.3267	—.0284	—.2919
78	.2079	—.4352	—.2894	.2211	.3143	—.0644	—.2943
79	.1908	—.4454	—.2688	.2443	.2990	—.0989	—.2913
80	.1736	—.4548	—.2474	.2659	.2810	—.1321	—.2835
81°	.1564	—.4633	—.2251	.2859	.2606	—.1635	—.2709
82	.1392	—.4709	—.2020	.3040	.2378	—.1926	—.2536
83	.1219	—.4777	—.1783	.3203	.2129	—.2193	—.2321
84	.1045	—.4836	—.1539	.3345	.1861	—.2431	—.2067
85	.0872	—.4886	—.1291	.3468	.1577	—.2638	—.1779
86°	.0698	—.4927	—.1038	.3569	.1278	—.2811	—.1460
87	.0523	—.4959	—.0781	.3648	.0969	—.2947	—.1117
88	.0349	—.4982	—.0522	.3704	.0651	—.3045	—.0735
89	.0175	—.4995	—.0262	.3739	.0327	—.3105	—.0381
90	.0000	—.5000	—.0000	.3750	.0000	—.3125	—.0000

TABLE 32.

MUTUAL INDUCTANCE.*

Values of log $\frac{M}{4\pi\sqrt{aa'}}$.

Table of values of log $\frac{M}{4\pi\sqrt{aa'}}$ for facilitating the calculation of the mutual inductance M of two coaxial circles of radii a, a', at distance apart b. The table is calculated for intervals of 6′ in the value of $\cos^{-1}\left\{\frac{(a-a')^2+b^2}{(a-a')^2+b^2}\right\}^{\frac{1}{2}}$ from 60° to 90°.

	0′	6′	12′	18′	24′	30′	36′	42′	48′	54′
60°	$\bar{1}$.4994783	5022651	5050505	5078345	5106173	5133989	5161791	5189582	5217361	5245128
61	5272883	5300628	5328361	5356084	5383796	5411498	5439190	5466872	5494545	5522209
62	5549864	5577510	5605147	5632776	5660398	5688011	5715618	5743217	5770809	5798394
63	5825973	5853546	5881113	5908675	5936231	5963782	5991322	6018871	6046408	6073942
64	6101472	6128998	6156522	6184042	6211560	6239076	6266589	6294101	6321612	6349121
65°	$\bar{1}$.6376629	6404137	6431645	6459153	6486660	6514169	6541678	6569189	6596701	6624215
66	6651732	6679250	6706772	6734296	6761824	6789356	6816891	6844431	6871976	6899526
67	6927081	6954642	6982209	7009782	7037362	7064949	7092544	7120146	7147756	7175375
68	7203003	7230640	7258286	7285942	7313609	7341287	7368975	7396675	7424387	7452111
69	7479848	7507597	7535361	7563138	7590929	7618735	7646556	7674392	7702245	7730114
70°	$\bar{1}$.7758000	7785903	7813823	7841762	7869720	7897696	7925692	7953709	7981745	8009803
71	8037882	8065983	8094107	8122253	8150423	8178617	8206836	8235080	8263349	8291645
72	8319967	8348316	8376693	8405099	8433534	8461998	8490493	8519018	8547575	8576164
73	8604785	8633440	8662129	8690852	8719611	8748406	8777237	8806106	8835013	8863958
74	8892943	8921969	8951036	8980144	9009295	9038489	9067728	9097012	9126341	9155717
75°	$\bar{1}$.9185141	9214613	9244135	9273707	9303330	9333005	9362733	9392515	9422352	9452246
76	9482196	9512205	9542272	9572400	9602590	9632841	9663157	9693537	9723983	9754497
77	9785079	9815731	9846454	9877249	9908118	9939062	9970082	$\overline{0001181}$	$\overline{0032359}$	$\overline{0063618}$
78	0.0094959	0126385	0157896	0189494	0221181	0252959	0284830	0316794	0348855	0381014
79	0413273	0445633	0478098	0510668	0543347	0576136	0609037	0642054	0675187	0708441
80°	0.0741816	0775316	0808944	0842702	0876592	0910619	0944784	0979091	1013542	1048142
81	1082893	1117799	1152863	1188089	1223481	1259043	1294778	1330691	1366786	1403067
82	1439539	1476207	1513075	1550149	1587434	1624935	1662658	1700609	1738794	1777219
83	1815890	1854815	1894001	1933455	1973184	2013197	2053502	2094108	2135026	2176259
84	2217823	2259728	2301983	2344600	2387591	2430970	2474748	2518940	2563561	2608626
85°	0.2654152	2700156	2746655	2793670	2841221	2889329	2938018	2987312	3037238	3087823
86	3139097	3191092	3243843	3297387	3351762	3407012	3463184	3520327	3578495	3637749
87	3698153	3759777	3822700	3887006	3952792	4020162	4089234	4160138	4233022	4308053
88	4385420	4465341	4548064	4633880	4723127	4816206	4913595	5015870	5123738	5238079
89	5360007	5490969	5632886	5788406	5961320	6157370	6385907	6663883	7027765	7586941

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* Quoted from Gray's "Absolute Measurements in Electricity and Magnetism," vol. ii., p. 852.

TABLE 33.

ELLIPTIC INTEGRALS.

Values of $\int_0^{\frac{\pi}{2}}(1-\sin^2\theta\sin^2\phi)^{\pm\frac{1}{2}}\,d\phi$.

This table gives the values of the integrals between 0 and $\pi/2$ of the function $(1-\sin^2\theta\sin^2\phi)^{\pm\frac{1}{2}}\,d\phi$ for different values of the modulus corresponding to each degree of θ between 0 and 90.

θ	$\int_0^{\frac{\pi}{2}}\frac{d\phi}{(1-\sin^2\theta\sin^2\phi)^{\frac{1}{2}}}$		$\int_0^{\frac{\pi}{2}}(1-\sin^2\theta\sin^2\phi)^{\frac{1}{2}}d\phi$		θ	$\int_0^{\frac{\pi}{2}}\frac{d\phi}{(1-\sin^2\theta\sin^2\phi)^{\frac{1}{2}}}$		$\int_0^{\frac{\pi}{2}}(1-\sin^2\theta\sin^2\phi)^{\frac{1}{2}}d\phi$	
	Number.	Log.	Number.	Log.		Number.	Log.	Number.	Log.
0°	1.5708	0.196120	1.5708	0.196120	45°	1.8541	0.268127	1.3506	0.130541
1	5709	196153	5707	196087	6	8691	271644	3418	127690
2	5713	196252	5703	195988	7	8848	275267	3329	124788
3	5719	196418	5697	195822	8	9011	279001	3238	121836
4	5727	196649	5689	195591	9	9180	282848	3147	118836
5°	1.5738	0.196947	1.5678	0.195293	50°	1.9356	0.286811	1.3055	0.115790
6	5751	197312	5665	194930	1	9539	290895	2963	112698
7	5767	197743	5649	194500	2	9729	295101	2870	109563
8	5785	198241	5632	194004	3	9927	299435	2776	106386
9	5805	198806	5611	193442	4	2.0133	303901	2681	103169
10°	1.5828	0.199438	1.5589	0.192815	55°	2.0347	0.308504	1.2587	0.099915
1	5854	200137	5564	192121	6	0571	313247	2492	096626
2	5882	200904	5537	191362	7	0804	318138	2397	093303
3	5913	201740	5507	190537	8	1047	323182	2301	089950
4	5946	202643	5476	189646	9	1300	328384	2206	086569
15°	1.5981	0.203615	1.5442	0.188690	60°	2.1565	0.333753	1.2111	0.083164
6	6020	204657	5405	187668	1	1842	339295	2015	079738
7	6061	205768	5367	186581	2	2132	345020	1920	076293
8	6105	206948	5326	185428	3	2435	350936	1826	072834
9	6151	208200	5283	184210	4	2754	357053	1732	069364
20°	1.6200	0.209522	1.5238	0.182928	65°	2.3088	0.363384	1.1638	0.065889
1	6252	210916	5191	181580	6	3439	369940	1545	062412
2	6307	212382	5141	180168	7	3809	376736	1453	058937
3	6365	213921	5090	178691	8	4198	383787	1362	055472
4	6426	215533	5037	177150	9	4610	391112	1272	052020
25°	1.6490	0.217219	1.4981	0.175545	70°	2.5046	0.398730	1.1184	0.048589
6	6557	218981	4924	173876	1	5507	406665	1096	045183
7	6627	220818	4864	172144	2	5998	414943	1011	041812
8	6701	222732	4803	170348	3	6521	423596	0927	038481
9	6777	224723	4740	168489	4	7081	432660	0844	035200
30°	1.6858	0.226793	1.4675	0.166567	75°	2.7681	0.442176	1.0764	0.031976
1	6941	228943	4608	164583	6	8327	452196	0686	028819
2	7028	231173	4539	162537	7	9026	462782	0611	025740
3	7119	233485	4469	160429	8	9786	474008	0538	022749
4	7214	235880	4397	158261	9	3.0617	485967	0468	019858
35°	1.7312	0.238359	1.4323	0.156031	80°	3.1534	0.498777	1.0401	0.017081
6	7415	240923	4248	153742	1	2553	512591	0338	014432
7	7522	243575	4171	151393	2	3699	527613	0278	011927
8	7633	246315	4092	148985	3	5004	544120	0223	009584
9	7748	249146	4013	146519	4	6519	562514	0172	007422
40°	1.7868	0.252068	1.3931	0.143995	85°	3.8317	0.583396	1.0127	0.005465
1	7992	255085	3849	141414	6	4.0528	607751	0086	003740
2	8122	258197	3765	138778	7	3387	637355	0053	002278
3	8256	261406	3680	136086	8	7427	676027	0026	001121
4	8396	264716	3594	133340	9	5.4349	735192	0008	000326
45°	1.8541	0.268127	1.3506	0.130541	90°	∞	∞	1.0000	———

TABLE 34.

MOMENTS OF INERTIA, RADII OF GYRATION, AND WEIGHTS.

In each case the axis is supposed to traverse the centre of gravity of the body. The axis is one of symmetry. The mass of a unit of volume is w.

Body.	Axis.	Weight.	Moment of Inertia I_0.	Square of Radius of Gyration ρ_0^2.
Sphere of radius r	Diameter	$\frac{4\pi w r^3}{3}$	$\frac{8\pi w r^5}{15}$	$\frac{2r^2}{5}$
Spheroid of revolution, polar axis $2a$, equatorial diameter $2r$	Polar axis	$\frac{4\pi w a r^2}{3}$	$\frac{8\pi w a r^4}{15}$	$\frac{2r^2}{5}$
Ellipsoid, axes $2a$, $2b$, $2c$	Axis $2a$	$\frac{4\pi w a b c}{3}$	$\frac{4\pi w a b c(b^2+c^2)}{15}$	$\frac{b^2+c^2}{5}$
Spherical shell, external radius r, internal r'	Diameter	$\frac{4\pi w(r^3-r'^3)}{3}$	$\frac{8\pi w(r^5-r'^5)}{15}$	$\frac{2(r^5-r'^5)}{5(r^3-r'^3)}$
Ditto, insensibly thin, radius r, thickness dr	Diameter	$4\pi w r^2 dr$	$\frac{8\pi w r^4 dr}{3}$	$\frac{2r^2}{3}$
Circular cylinder, length $2a$, radius r	Longitudinal axis $2a$	$2\pi w a r^2$	$\pi w a r^4$	$\frac{r^2}{2}$
Elliptic cylinder, length $2a$, transverse axes $2b$, $2c$	Longitudinal axis $2a$	$2\pi w a b c$	$\frac{\pi w a b c(b^2+c^2)}{2}$	$\frac{b^2+c^2}{4}$
Hollow circular cylinder, length $2a$, external radius r, internal r'	Longitudinal axis $2a$	$2\pi w a(r^2-r'^2)$	$\pi w a(r^4-r'^4)$	$\frac{r^2+r'^2}{2}$
Ditto, insensibly thin, thickness dr	Longitudinal axis $2a$	$4\pi w a r dr$	$4\pi w a r^3 dr$	r^2
Circular cylinder, length $2a$, radius r	Transverse diameter	$2\pi w a r^2$	$\frac{\pi w a r^2(3r^2+4a^2)}{6}$	$\frac{r^2}{4}+\frac{a^2}{3}$
Elliptic cylinder, length $2a$, transverse axes $2a$, $2b$	Transverse axis $2b$	$2\pi w a b c$	$\frac{\pi w a b c(3c^2+4a^2)}{6}$	$\frac{c^2}{4}+\frac{a^2}{3}$
Hollow circular cylinder, length $2a$, external radius r, internal r'	Transverse diameter	$2\pi w a(r^2-r'^2)$	$\frac{\pi w a}{6}\left\{\begin{array}{l}3(r^4-r'^4)\\+4a^2(r^2-r'^2)\end{array}\right\}$	$\frac{r^2+r'^2}{4}+\frac{a^2}{3}$
Ditto, insensibly thin, thickness dr	Transverse diameter	$4\pi w a r dr$	$\pi w a(2r^3+\frac{4}{3}a^2 r)dr$	$\frac{r^2}{2}+\frac{a^2}{3}$
Rectangular prism, dimensions $2a$, $2b$, $2c$	Axis $2a$	$8wabc$	$\frac{8wabc(b^2+c^2)}{3}$	$\frac{b^2+c^2}{3}$
Rhombic prism, length $2a$, diagonals $2b$, $2c$	Axis $2a$	$4wabc$	$\frac{2wabc(b^2+c^2)}{3}$	$\frac{b^2+c^2}{6}$
Ditto	Diagonal $2b$	$4wabc$	$\frac{2wabc(c^2+2a^2)}{3}$	$\frac{c^2}{6}+\frac{a^2}{3}$

(Taken from Rankine.)

TABLES 35-36.

BRITISH GAUGE NUMBERS AND SIZES OF WIRES.

For Brown & Sharp American Gauge and Electrical Constants see Tables 40 and 41.

TABLE 35.—British Standard Wire Gauge.

Gauge Number	Diameter in Inches.	Section in Sq. Inches.	Diameter in Centimetres.	Section in Sq. Cms.
7–0	0.500	0.1963	1.2700	.1.267
6–0	.464	.1691	.1786	.091
5–0	0.432	0.1466	1.0973	0.9456
4–0	.400	.1257	.0160	.8107
3–0	.372	.1087	0.9449	.7012
2–0	.348	.0951	.8839	.6136
0	.324	.0825	.8230	.5319
1	0.300	0.07069	0.7620	0.4560
2	.276	.05983	.7010	.3858
3	.252	.04988	.6401	.3218
4	.232	.04227	.5893	.2727
5	.212	.03530	.5385	.2277
6	0.192	0.02895	0.4877	0.18679
7	.176	.02433	.4470	.15696
8	.160	.02010	.4064	.12973
9	.144	.01629	.3658	.10507
10	.128	.01287	.3251	.08302
11	0.116	0.010568	0.2946	0.06818
12	.104	.008495	.2642	.05480
13	.092	.006648	.2337	.04289
14	.080	.005027	.2032	.03243
15	.072	.004071	.1829	.02627
16	0.064	0.003217	0.16256	0.020755
17	.056	.002463	.14224	.015890
18	.048	.001810	.12192	.011675
19	.040	.001257	.10160	.008107
20	.036	.001018	.09144	.006567
21	0.032	0.0008042	0.08128	0.005189
22	.028	.0006158	.07112	.003973
23	.024	.0004524	.06096	.002922
24	.022	.0003801	.05588	.002452
25	.020	.0003142	.05080	.002027
26	0.0180	0.0002545	0.04572	0.0016417
27	.0164	.0002112	.04166	.0013628
28	.0148	.0001728	.03759	.0011099
29	.0136	.0001453	.03454	.0009363
30	.0124	.0001208	.03150	.0007791
31	0.0116	0.00010568	0.02946	0.0006818
32	.0108	.00009161	.02743	.0005910
33	.0100	.00007854	.02540	.0005067
34	.0092	.00006648	.02337	.0004289
35	.0084	.00005542	.02134	.0003575
36	0.0076	0.00004536	0.01930	0.0002927
37	.0068	.00003632	.01727	.0002343
38	.0060	.00002827	.01524	.0001824
39	.0052	.00002124	.01321	.0001370
40	.0048	.00001810	.01219	.0001167
41	0.0044	0.00001521	0.01118	0.0000982
42	.0040	.00001257	.01016	.0000811
43	.0036	.00001018	.00914	.0000656
44	.0032	.00000804	.00813	.0000519
45	.0028	.00000616	.00711	.0000397
46	0.0024	0.00000452	0.00610	0.0000292
47	.0020	.00000314	.00508	.0000203
48	.0016	.00000201	.00406	.0000129
49	.0012	.00000113	.00305	.0000073
50	.0010	.00000079	.00254	.0000051

TABLE 36.—Birmingham Wire Gauge.

Gauge Number.	Diameter in Inches.	Sections in Sq. Inches.	Diameter in Centimetres.	Section in Sq. Cms.
0000	0.454	0.16188	1.1532	1.0444
000	.425	.14186	.0795	.9152
00	.380	.11341	0.9652	.7317
0	.340	.09079	.8636	.5858
1	0.300	0.07069	0.7620	0.4560
2	.284	.06335	.7214	.4087
3	.259	.05269	.6579	.3399
4	.238	.04449	.6045	.2870
5	.220	.03801	.5588	.2452
6	0.203	0.03237	0.5156	0.20881
7	.180	.02545	.4572	.16417
8	.165	.02138	.4191	.13795
9	.148	.01720	.3759	.11099
10	.134	.01410	.3404	.09098
11	0.120	0.011310	0.3048	0.07297
12	.109	.009331	.2769	.06160
13	.095	.007088	.2413	.04573
14	.083	.005411	.2108	.03491
15	.072	.004072	.1829	.02627
16	0.065	0.0033183	0.16510	0.021409
17	.058	.0026421	.14732	.017046
18	.049	.0018857	.12446	.012166
19	.042	.0013854	.10668	.008938
20	.035	.0009621	.08890	.006207
21	0.032	0.0008042	0.08128	0.005189
22	.028	.0006158	.07112	.003973
23	.025	.0004909	.06350	.003167
24	.022	.0003801	.05588	.002452
25	.020	.0003142	.05080	.002027
26	0.018	0.0002545	0.04572	0.0016417
27	.016	.0002011	.04064	.0012972
28	.014	.0001539	.03556	.0009932
29	.013	.0001327	.03302	.0008563
30	.012	.0001181	.03048	.0007297
31	0.010	0.00007854	0.02540	0.0005067
32	.009	.00006362	.02286	.0004104
33	.008	.00005027	.02032	.0003243
34	.007	.00003848	.01778	.0002483
35	.005	.00001963	.01270	.0001267
36	0.004	0.00001257	0.01016	0.0000811

Table 37.

BRITISH UNITS.

Cross sections and weights of wires.

This table gives the cross section and weights in British units of copper, iron, and brass wires of the diameters given in the first column. For one tenth the diameter divide section and weights by 100. For ten times the diameter multiply by 100, and so on.

Diam. in Mils.	Area of cross section in Sq. Mils.	Copper — Density 8.90.			Iron — Density 7.80.			Brass — Density 8.56.		
		Pounds per Foot.	Log.	Feet per Pound.	Pounds per Foot.	Log.	Feet per Pound.	Pounds per Foot.	Log.	Feet per Pound.
10	78.54	.000303	$\bar{4}$.48150	3300.	.0002656	$\bar{4}$.42420	3765.	.0002915	$\bar{4}$ 46458	3431.
11	95.03	0367	.56429	2727.	03214	.50697	3112.	03527	54735	2836.
12	113.10	0436	.63986	2291.	03825	.58257	2615.	04197	62295	2383.
13	132.73	0512	.70939	1953.	04488	.65208	2228.	04926	69246	2030.
14	153.94	0594	.77376	1683.	05206	.71646	1921.	05713	75684	1750.
15	176.71	.000682	$\bar{4}$.83368	1467.	.0005976	$\bar{4}$.77637	1674.	.0006558	$\bar{4}$.81675	1525.
16	201.06	0776	.88974	1289.	06799	.83244	1471.	07461	.87282	1340.
17	226.98	0876	.94240	1142.	07675	.88510	1303.	08423	.92548	1187.
18	254.47	0982	_.99205	1018.	08605	.93475	1162.	09443	_.97513	1059.
19	283.53	1094	$\bar{3}$.03902	914.	09588	.98171	1043.	.0010522	$\bar{3}$.02209	950.
20	314.16	.001212	$\bar{3}$.08357	825.1	.001062	$\bar{3}$.02626	941.4	.001166	$\bar{3}$.06664	857.7
21	346.36	1336	.12594	748.3	1171	.06864	853.8	1285	.10902	778.0
22	380.13	1467	.16634	681.8	1286	.10904	777.8	1411	.14942	708.9
23	415.48	1603	.20496	623.8	1405	.14766	711.7	1542	.18804	648.6
24	452.39	1746	.24192	572.9	1530	.18463	653.7	1679	.22500	595.7
25	490.87	.001894	$\bar{3}$.27738	528.0	.001660	$\bar{3}$.22008	602.4	.001822	$\bar{3}$.26046	549.0
26	530.93	2046	.31146	488.1	1795	.25415	557.0	1970	.29453	507.5
27	572.56	2209	.34423	452.6	1936	.28693	516.5	2125	.32731	470.6
28	615.75	2376	.37583	420.9	2082	.31852	480.3	2285	.35890	437.6
29	660.52	2549	.40630	392.4	2234	.34900	447.7	2451	.38938	408.0
30	706.86	.002727	$\bar{3}$.43575	366.7	.002390	$\bar{3}$.37845	418.4	.002623	$\bar{3}$.41882	381.2
31	754.77	2912	.46424	343.4	2552	.40693	391.8	2801	.44731	357.0
32	804.25	3103	.49181	322.2	2720	.43450	367.7	2985	.47488	335.1
33	855.30	3300	.51854	303.0	2892	.46123	345.8	3174	.50161	315.1
34	907.92	3503	.54446	285.4	3070	.48716	325.7	3369	.52754	296.8
35	962.11	.003712	$\bar{3}$.56964	269.4	.003253	$\bar{3}$.51233	307.4	.003570	$\bar{3}$.55271	280.1
36	1017.88	3927	.59412	254.6	3442	.53691	290.5	3777	.57719	264.7
37	1075.21	4149	.61791	241.0	3636	.56061	275.0	3990	.60098	250.6
38	1134.11	4376	.64108	228.5	3844	.58476	260.2	4218	.62514	237.1
39	1194.59	4609	.66364	216.9	4040	.60633	247.6	4433	.64671	225.6
40	1256.64	.004849	$\bar{3}$.68563	206.2	.004249	$\bar{3}$.62833	235.3	.004664	$\bar{3}$.66871	214.4
41	1320.25	5094	.70708	196.3	4465	.64977	224.0	4900	.69015	204.1
42	1385.44	5346	.72801	187.1	4685	.67070	213.5	5141	.71108	194.5
43	1452.20	5603	.74845	178.5	4911	.69114	203.6	5389	.73152	185.6
44	1520.53	5867	.76842	170.4	5142	.71111	194.5	5643	.75149	177.2
45	1590.43	.006137	$\bar{3}$.78793	162.9	.005378	$\bar{3}$.73063	185.9	.005902	$\bar{3}$.77101	169.4
46	1661.90	6412	.80703	155.9	5620	.74972	177.9	6167	.79010	162.1
47	1734.94	6694	.82569	149.4	5867	.76840	170.5	6438	.80878	155.3
48	1809.56	6982	.84399	143.2	6119	.78669	163.4	6715	.82706	148.9
49	1885.74	7276	.86189	137.4	6377	.80459	156.8	6998	.84497	142.9
50	1963.50	.007576	$\bar{3}$.87945	132.0	.006640	$\bar{3}$.82214	150.6	.007287	$\bar{3}$.86252	137.2
51	2042.82	7882	.89664	126.9	6908	.83934	144.8	7581	.87972	131.9
52	2123.72	8194	.91352	122.0	7181	.85621	139.2	7881	.89659	126.9
53	2206.18	8512	.93005	117.5	7460	.87275	134.0	8187	.91313	122.1
54	2290.22	8837	.94630	113.2	7744	.88899	129.1	8499	.92937	117.7
55	2375.83	.009167	$\bar{3}$.96223	109.1	.008034	$\bar{3}$.90493	124.5	.008817	$\bar{3}$.94531	113.4

TABLE 37 (*continued*).

BRITISH UNITS.

Cross sections and weights of wires.

Diam. in Mils.	Area of cross section in Sq. Mils.	Copper — Density 8.90.			Iron — Density 7.80.			Brass — Density 8.56.		
		Pounds per Foot.	Log.	Feet per Pound.	Pounds per Foot.	Log.	Feet per Pound.	Pounds per Foot.	Log.	Feet per Pound.
55	2375.83	.009167	$\bar{3}$.96223	109.1	.008034	$\bar{3}$.90493	124.5	.008817	$\bar{3}$.94531	113.4
56	2463.01	09504	.97789	105.2	08329	.92058	120.1	09140	.96096	109.4
57	2551.76	09846	_.99325	101.6	08629	.93595	115.9	09470	.97633	105.6
58	2642.08	10195	$\bar{2}$.00837	98.1	08934	.95106	111.9	09805	_.99144	102.0
59	2733.97	10549	.02320	94.8	09245	.96591	108.2	10146	$\bar{2}$.00629	98.6
60	2827.43	.01091	$\bar{2}$.03782	91.66	.00956	$\bar{3}$.98050	104.59	.01049	$\bar{2}$.02088	95.30
61	2922.47	1128	.05216	88.68	0988	_.99486	101.19	1085	.03524	92.21
62	3019.07	1165	.06628	85.84	1021	$\bar{2}$.00898	97.95	1120	.04936	89.25
63	3117.25	1203	.08019	83.14	1054	.02288	94.87	1157	.06326	86.45
64	3216.99	1241	.09386	80.56	1088	.03656	91.83	1194	.07694	83.77
65	3318.31	.01280	$\bar{2}$.10732	78.11	.01122	$\bar{2}$.05003	89.12	.01231	$\bar{2}$.09041	81.21
66	3421.19	1320	.12061	75.76	1157	.06329	86.44	1270	.10367	78.76
67	3525.65	1360	.13367	73.51	1192	.07635	83.88	1308	.11673	76.43
68	3631.68	1401	.14655	71.36	1228	.08922	81.42	1348	.12960	74.20
69	3739.28	1443	.15924	69.30	1264	.10190	79.09	1388	.14228	72.06
70	3848.45	.01485	$\bar{2}$.17174	67.34	.01302	$\bar{2}$.11451	76.82	.01429	$\bar{2}$.15489	70.00
71	3959.19	1528	.18404	65.46	1339	.12672	74.69	1469	.16710	68.06
72	4071.50	1571	.19618	63.65	1377	.13887	72.63	1511	.17925	66.19
73	4185.39	1615	.20817	61.92	1415	.15085	70.66	1553	.19123	64.38
74	4300.84	1660	.22000	60.26	1454	.16267	68.76	1596	.20304	62.66
75	4417.86	.01705	$\bar{2}$.23165	58.66	.01494	$\bar{2}$.17432	66.95	.01639	$\bar{2}$.21460	61.01
76	4536.46	1751	.24317	57.13	1534	.18583	65.19	1684	.22621	59.40
77	4656.63	1797	.25453	55.65	1575	.19718	63.50	1728	.23756	57.87
78	4778.36	1844	.26574	54.23	1616	.20839	61.89	1773	.24877	56.39
79	4901.67	1892	.27681	52.87	1658	.21946	60.33	1819	.25974	54.99
80	5026.55	.01939	$\bar{2}$.28769	51.56	.01700	$\bar{2}$.23038	58.83	.01865	$\bar{2}$.27076	53.61
81	5153.00	1988	.29848	50.29	1743	.24117	57.39	1912	.28155	52.29
82	5281.02	2038	.30914	49.07	1786	.25183	56.00	1960	.29221	51.03
83	5410.61	2088	.31966	47.90	1830	.26236	54.66	2008	.30274	49.80
84	5541.77	2138	.33006	46.77	1874	.27276	53.36	2057	.31314	48.63
85	5674.50	.02189	$\bar{2}$.34034	45.67	.01919	$\bar{2}$.28304	52.11	.02106	$\bar{2}$.32342	47.49
86	5808.80	2241	.35050	44.62	1964	.29320	50.91	2156	.33358	46.39
87	5944.68	2294	.36054	43.60	2010	.30324	49.75	2206	.34362	45.33
88	6082.12	2347	.37047	42.61	2057	.31317	48.62	2257	.35355	44.30
89	6221.14	2400	.38028	41.66	2104	.32298	47.54	2309	.36336	43.31
90	6361.73	.02455	$\bar{2}$.38999	40.74	.02151	$\bar{2}$.33269	46.49	.02360	$\bar{2}$.37297	42.37
91	6503.88	2509	.39958	39.85	2199	.34228	45.47	2414	.38266	41.43
92	6647.61	2565	.40908	38.99	2248	.35178	44.49	2467	.39216	40.54
93	6792.91	2621	.41847	38.15	2297	.36116	43.54	2521	.40154	39.67
94	6939.78	2678	.42775	37.35	2347	.37046	42.61	2575	.41084	38.83
95	7088.22	.02735	$\bar{2}$.43694	36.56	.02397	$\bar{2}$.37965	41.72	.02630	$\bar{2}$.42003	38.02
96	7238.23	2793	.44604	35.81	2448	.38874	40.86	2686	.42912	37.23
97	7389.81	2851	.45504	35.07	2499	.39775	40.02	2742	.43812	36.46
98	7542.96	2910	.46395	34.36	2551	.40665	39.20	2799	.44703	35.72
99	7697.69	2970	.47277	33.67	2603	.41547	38.42	2857	.45585	35.01
100	7853.98	.03030	$\bar{2}$.48150	33.00	.02656	$\bar{2}$.42420	37.65	.02915	$\bar{2}$.46458	34.31

TABLE 38.

METRIC UNITS.

Cross sections and weights of wires.

This table gives the cross section and the weight in metric units of copper, iron, and brass wires of the diameters given in the first column. For one tenth the diameter divide sections and weights by 100. For ten times the diameter multiply by 100, and so on.

Diam. in thousandths of a cm.	Area of cross section $(\frac{cm}{1000})^2$	Copper — Density 8.90.			Iron — Density 7.80.			Brass — Density 8.56.		
		Grammes per Metre.	Log.	Metres per Gramme.	Grammes per Metre.	Log.	Metres per Gramme.	Grammes per Metre.	Log.	Metres per Gramme.
10	78.54	0.06990	$\bar{2}.84448$	14.306	0.06126	$\bar{2}.78718$	16.324	0.06723	$\bar{2}.82756$	14.874
11	95.03	.08458	.92725	11.823	.07412	.86996	13.492	.08135	.91034	12.293
12	113.10	.10065	$\bar{1}.00285$	9.935	.08822	.94556	11.335	.09681	.98594	10.330
13	132.73	.11813	.07236	8.465	.10353	$\bar{1}.01506$	9.659	.11362	$\bar{1}.05544$	8.801
14	153.94	.13701	.13674	7.299	.12008	.07945	8.328	.13177	.11983	7.589
15	176.71	0.1573	$\bar{1}.19665$	6.358	0.1378	$\bar{1}.13936$	7.255	0.1513	$\bar{1}.17974$	6.611
16	201.06	.1789	.25272	5.588	.1568	.19542	6.376	.1721	.23580	5.810
17	226.98	.2020	.30538	4.951	.1770	.24808	5.648	.1943	.28846	5.147
18	254.47	.2265	.35503	4.415	.1985	.29773	5.038	.2178	.33811	4.591
19	283.53	.2523	.40199	3.963	.2212	.34469	4.522	.2427	.38507	4.120
20	314.16	0.2796	$\bar{1}.44654$	3.577	0.2450	$\bar{1}.38925$	4.081	0.2689	$\bar{1}.42963$	3.719
21	346.36	.3083	.48892	.244	.2702	.43162	3.701	.2965	.47200	.373
22	380.13	.3383	.52932	2.956	.2965	.47203	.373	.3254	.51241	.073
23	415.48	.3698	.56794	.704	.3241	.51064	.086	.3557	.55103	2.812
24	452.39	.4026.	.60490	.484	.3529	.54761	2.834	.3872	.58799	.582
25	490.87	0.4369	$\bar{1}.64036$	2.289	0.3829	$\bar{1}.58306$	2.612	0.4202	$\bar{1}.62344$	2.380
26	530.93	.4725	.67443	.116	.4141	.61713	.415	.4545	.65751	.200
27	572.56	.5096	.70721	1.962	.4466	.64992	.239	.4901	.69030	.040
28	615.75	.5480	.73880	.825	.4803	.68150	.082	.5271	.72188	1.897
29	660.52	.5879	.76928	.701	.5152	.71198	1.941	.5654	.75236	.769
30	706.86	0.6291	$\bar{1}.79872$	1.590	0.5514	$\bar{1}.74143$	1.814	0.6051	$\bar{1}.78181$	1.653
31	754.77	.6717	.82721	.489	.5887	.76991	.699	.6461	.81029	.548
32	804.25	.7158	.85478	.397	.6273	.79749	.594	.6884	.83787	.453
33	855.30	.7612	.88151	.314	.6671	.82421	.499	.7321	.86459	.366
34	907.92	.8081	.90744	.238	.7082	.85014	.412	.7772	.89052	.287
35	962.11	0.856	$\bar{1}.93261$	1.168	0.7504	$\bar{1}.87531$	1.333	0.8236	$\bar{1}.91570$	1.214
36	1017.88	.906	.95709	.104	.7939	.89979	.260	.8713	.94017	.148
37	1075.21	.957	.98088	.045	.8387	.92359	.192	.9204	.96397	.087
38	1134.11	1.012	0.00504	0.988	.8866	.94775	.128	.9730	.98813	.028
39	1194.59	.063	.02661	.941	.9318	.96931	.073	1.0230	0.00969	0.978
40	1256.64	1.118	0.04861	0.8941	0.980	$\bar{1}.99131$	1.0200	1.076	0.03169	0.9296
41	1320.25	.175	.07005	.8511	1.030	0.01275	0.9711	.130	.05313	.8849
42	1385.44	.233	.09098	.8110	.081	.03368	.9254	.186	.07406	.8432
43	1452.20	.292	.11142	.7738	.133	.05412	.8828	.243	.09450	.8044
44	1520.53	.353	.13139	.7389	.186	.07409	.8432	.302	.11447	.7683
45	1590.43	1.415	0.15091	0.7065	1.241	0.09361	0.8061	1.361	0.13399	0.7345
46	1661.90	.479	.17000	.6761	.296	.11270	.7714	.423	.15308	.7029
47	1734.94	.544	.18868	.6476	.353	.13138	.7389	.485	.17176	.6734
48	1809.56	.611	.20696	.6209	.411	.14967	.7085	.549	.19005	.6456
49	1885.74	.678	.22487	.5958	.471	.16758	.6799	.614	.20796	.6195
50	1963.50	1.748	0.24242	0.5722	1.532	0.18513	0.6530	1.681	0.22551	0.5950
51	2042.82	.818	.25962	.5500	.593	.20232	.6276	.753	.24371	.5705
52	2123.72	.890	.27649	.5291	.657	.21919	.6037	.818	.25957	.5501
53	2206.18	.964	.29303	.5093	.721	.23574	.5811	.888	.27612	.5295
54	2290.22	2.038	.30927	.4906	.786	.25197	.5598	.960	.29235	.5101
55	2375.83	2.114	0.32521	0.4729	1.853	0.26791	0.5396	2.034	0.30829	0.4917

METRIC UNITS.

Cross sections and weights of wires.

Diam. in thousandths of a cm.	Area of cross section $(\frac{\text{cm.}}{1000})^2$	Copper — Density 8.90.			Iron — Density 7.80.			Brass — Density 8.56.		
		Grammes per Metre.	Log.	Metres per Gramme.	Grammes per Metre.	Log.	Metres per Gramme.	Grammes per Metre.	Log.	Metres per Gramme.
55	2375.83	2.114	0.32521	.4729	1.853	0.26791	.5396	2.034	0.30829	.4917
56	2463.01	.192	.34086	.4562	.921	.28356	.5205	.108	.32394	.4743
57	2551.76	.271	.35623	.4403	.990	.29893	.5024	.184	.33931	.4578
58	2642.08	.351	.37134	.4253	2.061	.31404	.4852	.262	.35442	.4422
59	2733.97	.433	.38618	.4112	.132	.32889	.4689	.340	.36927	.4273
60	2827.43	2.516	0.40078	.3974	2.205	0.34349	.4534	2.420	0.38387	.4132
61	2922.47	.601	.41514	.3845	.280	.35784	.4387	.502	.39823	.3997
62	3019.07	.687	.42926	.3722	.355	.37196	.4246	.584	.41235	.3869
63	3117.25	.774	.44316	.3604	.431	.38587	.4113	.668	.42625	.3748
64	3216.99	.863	.45684	.3493	.509	.39954	.3985	.760	.44092	.3623
65	3318.31	2.953	0.47031	.3386	2.588	0.41301	.3864	2.840	0.45339	.3521
66	3421.19	3.045	.48357	.3284	.669	.42627	.3747	.929	.46665	.3415
67	3525.65	.138	.49663	.3187	.750	.43933	.3636	3.018	.47971	.3313
68	3631.68	.232	.50950	.3094	.833	.45220	.3530	.109	.49258	.3217
69	3739.28	.328	.52218	.3005	.917	.46488	.3429	.201	.50526	.3124
70	3848.45	3.426	0.53479	.2919	3.003	0.47749	.3330	3.295	0.51787	.3035
71	3959.19	.524	.54700	.2838	.088	.48970	.3238	.389	.53008	.2951
72	4071.50	.624	.55915	.2759	.176	.50185	.3149	.485	.54223	.2869
73	4185.39	.725	.57113	.2685	.265	.51383	.3063	.583	.55421	.2791
74	4300.84	.828	.58294	.2612	.355	.52565	.2981	.682	.56603	.2716
75	4417.86	3.932	0.59460	.2543	3.446	0.53731	.2902	3.782	0.57769	.2644
76	4536.46	4.037	.60611	.2477	.538	.54881	.2826	.883	.58919	.2575
77	4656.63	.144	.61746	.2413	.632	.56017	.2753	.986	.60056	.2509
78	4778.36	.253	.62867	.2351	.727	.57137	.2683	4.090	.61175	.2445
79	4901.67	.362	.63974	.2292	.823	.58244	.2615	.177	.62283	.2394
80	5026.55	4.474	0.65066	.2235	3.921	0.59336	.2550	4.303	0.63375	.2324
81	5153.00	.586	.66145	.2180	4.019	.60415	.2488	.411	.64454	.2267
82	5281.02	.700	.67211	.2128	.119	.61481	.2428	.521	.65519	.2212
83	5410.61	.815	.68264	.2077	.220	.62534	.2369	.631	.66572	.2159
84	5541.77	.932	.69304	.2027	.323	.63574	.2313	.744	.67612	.2108
85	5674.50	5.050	0.70332	.1980	4.426	0.64602	.2259	4.857	0.68640	.2059
86	5808.80	.170	.71348	.1934	.531	.65618	.2207	.972	.69656	.2011
87	5944.68	.291	.72352	.1890	.637	.66622	.2157	5.089	.70660	.1965
88	6082.12	.413	.73345	.1847	.744	.67615	.2108	.206	.71653	.1921
89	6221.14	.537	.74326	.1806	.852	.68596	.2061	.325	.72634	.1878
90	6361.73	5.662	0.75297	.1766	4.962	0.69567	.2015	5.446	0.73605	.1836
91	6503.88	.788	.76256	.1728	5.073	.70527	.1971	.567	.74565	.1796
92	6647.61	.916	.77206	.1690	.185	.71476	.1929	.690	.75514	.1757
93	6792.91	6.046	.78144	.1654	.298	.72414	.1887	.815	.76452	.1720
94	6939.78	.176	.79074	.1619	.413	.73344	.1847	.940	.77382	.1683
95	7088.22	6.309	0.79993	.1585	5.529	0.74263	.1809	6.068	0.78301	.1648
96	7238.23	.442	.80902	.1552	.646	.75173	.1771	.196	.79211	.1614
97	7389.81	.577	.81802	.1520	.764	.76073	.1735	.326	.80111	.1581
98	7542.96	.713	.82693	.1490	.884	.76964	.1670	.457	.81002	.1549
99	7697.69	.851	.83575	.1460	6.004	.77846	.1665	.589	.81884	.1518
100	7853.98	6.990	0.84448	.1431	6.126	0.78718	.1632	6.723	0.82756	.1487

TABLE 39.

BRITISH AND METRIC UNITS.

Cross sections and weights of wires.

The cross section and the weight, in different units, of Aluminium wire of the diameters given in the first column. For one tenth the diameter divide sections and weights by 100. For ten times the diameter multiply by 100, and so on.

Diameter.*	Area of cross section.*	Aluminium — Density 2.67.									
		Pounds per Foot.	Log.	Feet per Pound.	Ounces per Foot.	Log.	Feet per Ounce.	Grammes per Metre.*	Log.	Metres per Gramme.
10	78.54	.0000909	$\bar{5}.95862$	11000.	.001455	$\bar{3}.16274$	687.5	.02097	$\bar{2}.32160$	47.69
11	95.03	01100	4.04139	9091.	01760	.24551	602.4	.02537	.40437	39.41
12	113.10	01309	.11699	7638.	02095	.32111	477.4	.03020	.47997	33.11
13	132.73	01536	.18650	6509.	02458	.39062	406.8	.03544	.54948	28.22
14	153.94	01782	.25088	5612.	02851	.45500	350.8	.04110	.61386	24.33
15	176.71	.0002045	$\bar{4}.31079$	4889.	.003273	$\bar{3}.51491$	305.6	.04718	$\bar{2}.67377$	21.19
16	201.06	02327	.36685	4297.	03724	.57097	268.5	.05368	.72984	18.63
17	226.98	02627	.41952	3876.	04204	.62364	237.9	.06060	.78250	16.50
18	254.47	02946	.46917	3395.	04713	.67329	212.2	.06794	.83215	14.72
19	283.53	03282	.51613	3047.	05251	.72025	190.4	.07570	.87911	13.21
20	314.16	.0003636	$\bar{4}.56068$	2750.	.005818	$\bar{3}.76480$	171.9	.08388	$\bar{2}.92366$	11.922
21	346.36	04009	.60306	2494.	06415	.80718	155.9	.09248	_.96604	10.813
22	380.13	04400	.64346	2273.	07040	.84758	142.0	.10149	$\bar{1}.00644$	9.853
23	415.48	04809	.68208	2079.	07697	.88630	129.9	.11093	.04506	9.014
24	452.39	05237	.71904	1910.	08378	.92316	119.4	.12079	.08202	8.279
25	490.87	.0005682	$\bar{4}.75450$	1760.	.00909	$\bar{3}.95862$	110.00	.1311	$\bar{1}.11748$	7.630
26	530.93	06147	.78867	1627.	0983	_.99269	101.70	.1418	.15155	7.054
27	572.56	06628	.82135	1509.	1060	$\bar{2}.02547$	94.30	.1529	.18433	6.541
28	615.75	07127	.85293	1403.	1140	.05705	87.69	.1644	.21592	6.083
29	660.52	07646	.88341	1308.	1223	.08753	81.75	.1764	.24640	5.670
30	706.86	.0008182	$\bar{4}.91286$	1222.	.01309	$\bar{2}.11698$	76.39	.1887	$\bar{1}.27584$	5.299
31	754.77	08737	.94134	1145.	1398	.14546	71.54	.2015	.30433	4.962
32	804.25	09309	.96892	1074.	1489	.17304	66.89	.2147	.33190	.657
33	855.30	09900	_.99565	1010.	1584	.19977	63.13	.2284	.35863	.379
34	907.92	10509	$\bar{3}.02158$	952.	1681	.22570	59.47	.2424	.38456	.125
35	962.11	.001114	$\bar{3}.04675$	897.9	.01782	$\bar{2}.25087$	56.12	.2569	$\bar{1}.40973$	3.893
36	1017.88	1178	.07123	848.8	1885	.27535	53.05	.2718	.43421	.680
37	1075.21	1245	.09502	803.5	1991	.29914	50.22	.2871	.45800	.483
38	1134.11	1316	.11918	760.0	2105	.32329	47.50	.3035	.48216	.295
39	1194.59	1383	.14075	723.2	2212	.34487	45.20	.3190	.50373	.135
40	1256.64	.001455	$\bar{3}.16275$	687.5	.02327	$\bar{2}.36687$	42.97	.3355	$\bar{1}.52573$	2.980
41	1320.25	1528	.18419	654.4	2445	.38831	40.90	.3525	.54717	.837
42	1385.44	1604	.20512	623.6	2566	.40924	38.97	.3699	.56810	.704
43	1452.20	1681	.22556	594.9	2690	.42968	37.18	.3877	.58854	.579
44	1520.53	1760	.24552	568.2	2816	.44964	35.51	.4060	.60851	.463
45	1590.43	.001841	$\bar{3}.26504$	543.2	.02946	$\bar{2}.46916$	33.95	.4246	$\bar{1}.62803$	2.355
46	1661.90	1924	.28413	519.8	3078	.48825	32.49	.4437	.64712	.254
47	1734.94	2008	.30281	498.0	3213	.50693	31.12	.4632	.66580	.159
48	1809.56	2095	.32110	477.4	3351	.52522	29.84	.4832	.68408	.070
49	1885.74	2183	.33901	458.1	3492	.54313	28.63	.5035	.70199	1.986
50	1963.50	.002273	$\bar{3}.35656$	440.0	.03636	$\bar{2}.56068$	27.50	.5243	$\bar{1}.71954$	1.907
51	2042.82	2365	.37376	422.9	3783	.57788	26.43	.5454	.73674	.833
52	2123.72	2458	.39063	406.8	3933	.59475	25.42	.5670	.75361	.764
53	2206.18	2554	.40717	394.2	4086	.61129	24.47	.5891	.77015	.698
54	2290.22	2651	.42341	377.2	4242	.62753	23.57	.6115	.78639	.635
55	2375.83	.002750	$\bar{3}.43934$	363.6	.04400	$\bar{2}.64346$	22.73	.6343	$\bar{1}.80233$	1.576

* Columns 3–8, in thousandths of an inch; 9–12, thousandths of a centimetre.

TABLE 39 (*continued*).

BRITISH AND METRIC UNITS.

Cross sections and weights of wires.

Diameter.*	Area of cross section.*	Aluminium — Density 2.67.								
		Pounds per Foot.	Log.	Feet per Pound.	Ounces per Foot.	Log.	Feet per Ounce.	Grammes per Metre.*	Log.	Metres per Gramme.
55	2375.83	.002750	$\bar{3}.43934$	363.6	.04400	$\bar{2}.64346$	22.73	0.6343	$\bar{1}.80233$	1.576
56	2463.01	2851	.45500	350.8	.04562	.65912	21.92	.6576	.81798	.521
57	2551.76	2954	.47037	338.6	.04726	.67449	21.16	.6813	.83335	.468
58	2642.08	3058	.48547	327.0	.04893	.68959	20.44	.7054	.84846	.418
59	2733.97	3165	.50032	316.0	.05063	.70444	19.75	.7300	.86331	.370
60	2827.43	.003273	$\bar{3}.51492$	305.5	.05236	$\bar{2}.71904$	19.10	0.7549	$\bar{1}.87790$	1.325
61	2922.47	3383	.52928	295.6	.05413	.73340	18.48	.7803	.89226	.282
62	3019.07	3495	.54340	286.2	.05591	.74752	17.88	.8061	.90638	.241
63	3117.25	3608	.55730	277.1	.05773	.76142	17.32	.8323	.92028	.201
64	3216.99	3724	.57098	268.5	.05958	.77510	16.78	8589	.93396	.164
65	3318.31	.003841	$\bar{3}.58445$	260.3	.06146	$\bar{2}.78857$	16.27	0.8860	$\bar{1}.94743$	1.129
66	3421.19	3960	.59771	252.5	.06336	.80183	15.78	.9135	.96069	.095
67	3525.65	4081	.61077	245.0	.06530	.81489	15.31	.9413	.97375	.062
68	3631.68	4204	.62364	237.9	.06726	.82777	14.87	.9697	.98662	.031
69	3739.28	4328	.63632	231.0	.06925	.84044	14.44	.9984	.99930	.002
70	3848.45	.004456	$\bar{3}.64893$	224.4	.07129	$\bar{2}.85305$	14.03	1.028	0.01191	0.9730
71	3959.19	4583	.66114	218.2	.07333	.86526	13.64	.057	.02412	.9460
72	4071.50	4713	.67328	212.2	.07541	.87740	13.26	.087	.03627	.9199
73	4185.39	4845	.68526	206.4	.07751	.88938	12.90	.117	.04825	.8949
74	4300.84	4978	.69708	200.9	.07965	.90120	12.55	.148	.06006	.8708
75	4417.86	.005114	$\bar{3}.70874$	195.5	.08182	$\bar{2}.91286$	12.22	1.180	0.07172	0.8477
76	4536.46	5251	.72025	190.4	.08402	.92437	11.90	.211	.08323	.8256
77	4656.63	5390	.73160	185.5	.08624	.93572	11.60	.243	.09458	.8043
78	4778.36	5531	.74281	180.8	.08850	.94693	11.30	.276	.10579	.7838
79	4901.67	5674	.75387	176.2	.09078	.95799	11.02	.309	.11686	.7641
80	5026.55	.005818	$\bar{3}.76480$	171.9	.09309	$\bar{2}.96892$	10.742	1.342	0.12778	0.7451
81	5153.00	5965	.77559	167.6	.09544	.97971	10.479	.376	.13857	.7268
82	5281.02	6113	.78625	163.6	.09781	.99037	10.224	.410	.14923	.7092
83	5410.61	6263	.79678	159.7	.10021	$\bar{1}.00090$	9.979	.445	.15976	.6922
84	5541.77	6415	.80718	155.9	.10264	.01130	9.743	.480	.17016	.6757
85	5674.50	.006568	$\bar{3}.81746$	152.2	.1051	$\bar{1}.02158$	9.515	1.515	0.18044	0.6600
86	5808.80	6724	.82762	148.7	.1076	.03174	9.295	.551	.19060	.6448
87	5944.68	6881	.83766	145.3	.1101	.04178	9.082	.587	.20064	.6300
88	6082.12	7040	.84758	142.0	.1126	.05170	8.878	.624	.21057	.6158
89	6221.14	7201	.85740	138.9	.1152	.06152	8.679	.661	.22038	.6020
90	6361.73	.007364	$\bar{3}.86710$	135.8	.1178	$\bar{1}.07122$	8.488	1.699	0.23009	0.5887
91	6503.88	7528	.87670	132.8	.1205	.08082	8.302	.737	.23968	.5759
92	6647.61	7695	.88619	130.0	.1231	.09031	8.122	.775	.24918	.5634
93	6792.91	7863	.89558	127.2	.1258	.09970	7.949	.814	.25856	.5514
94	6939.78	8033	.90487	124.5	.1285	.10899	7.780	.853	.26786	.5397
95	7088.22	.008205	$\bar{3}.91407$	121.9	.1313	$\bar{1}.11819$	7.617	1.893	0.27705	0.5284
96	7238.23	8378	.92316	119.4	.1341	.12728	7.459	.933	.28614	.5174
97	7389.81	8554	.93216	116.9	.1369	.13628	7.307	.973	.29514	.5068
98	7542.96	8731	.94107	114.5	.1397	.14519	7.158	2.014	.30405	.4965
99	7697.69	8910	.94989	112.2	.1426	.15401	7.015	.055	.31287	.4865
100	7853.98	.009091	$\bar{3}.95862$	110.0	.1455	$\bar{1}.16274$	6.875	2.097	0.32160	0.4769

* Columns 3–8, in thousandths of an inch; 9–12, thousandths of a centimetre.

Table 40.

SIZE, WEIGHT, AND ELECTRICAL

Size, Weight, and Electrical Constants of pure hard drawn Copper Wire of different numbers

Size and Weight.

Gauge Number.	Diameter in Inches.	Square of Diameter (Circular Inches).	Section in Sq. Inches.	Pounds per Foot.	Log.	Feet per Pound.
0000	0.4600	0.2116	0.1662	0.6412	$\bar{1}$.80701	1.560
000	.4096	.1678	.1318	.5085	.70631	1.967
00	.3648	.1331	.1045	.4033	.60560	2.480
0	.3249	.1055	.0829	.3198	.50489	3.127
1	0.2893	0.08369	0.06573	0.2536	$\bar{1}$.40419	3.943
2	.2576	.06637	.05213	.2011	.30348	4.972
3	.2294	.05263	.04134	.1595	.20277	6.270
4	.2043	.04174	.03278	.1265	.10206	7.905
5	.1819	.03310	.02600	.1003	.00136	9.969
6	0.1620	0.02625	0.02062	0.07955	$\bar{2}$.90065	12.57
7	.1443	.02082	.01635	.06309	.79994	15.85
8	.1285	.01651	.01297	.05003	.69924	19.99
9	.1144	.01309	.01028	.03968	.59853	25.20
10	.1019	.01038	.00815	.03146	.49782	31.78
11	0.09074	0.008234	0.006467	0.02495	$\bar{2}$.39711	40.08
12	.08081	.006530	.005129	.01979	.29641	50.54
13	.07196	.005178	.004067	.01569	.19570	63.72
14	.06408	.004107	.003225	.01244	.09499	80.35
15	.05707	.003257	.002558	.00987	$\bar{3}$.99429	101.32
16	0.05082	0.002583	0.002028	0.007827	$\bar{3}$.89358	127.8
17	.04526	.002048	.001609	.006207	.79287	161.1
18	.04030	.001624	.001276	.004922	.69217	203.2
19	.03589	.001288	.001012	.003904	.59146	256.2
20	.03196	.001021	.000802	.003096	.49075	323.1
21	0.02846	0.0008101	0.0006363	0.002455	$\bar{3}$.39004	408.2
22	.02535	.0006424	.0005046	.001947	.28934	513.6
23	.02257	.0005095	.0004001	.001544	.18863	647.7
24	.02010	.0004040	.0003173	.001224	.08792	816.7
25	.01790	.0003204	.0002517	.000971	$\bar{4}$.98722	1029.9
26	0.01594	0.0002541	0.0001996	0.0007700	$\bar{4}$.88651	1298.
27	.01419	.0002015	.0001583	.0006107	.78580	1638.
28	.01264	.0001598	.0001255	.0004843	.68510	2065.
29	.01126	.0001267	.0000995	.0003841	.58439	2604.
30	.01003	.0001005	.0000789	.0003046	.48368	3283.
31	0.008928	0.00007970	0.00006260	0.0002415	$\bar{4}$.38297	4140.
32	.007950	.00006321	.00004964	.0001915	.28227	5221.
33	.007080	.00005013	.00003937	.0001519	.18156	6583.
34	.006304	.00003975	.00003122	.0001205	.08085	8301.
35	.005614	.00003152	.00002476	.0000955	$\bar{5}$.98015	10468.
36	0.005000	0.00002500	0.00001963	0.00007576	$\bar{5}$.87944	13200.
37	.004453	.00001983	.00001557	.00006008	.77873	16644.
38	.003965	.00001372	.00001235	.00004765	.67802	20988.
39	.003531	.00001247	.00000979	.00003778	.57732	26465.
40	.003145	.00000989	.00000777	.00002996	.47661	33372.

CONSTANTS OF COPPER WIRE.

according to the American Brown and Sharp Gauge. Common Measure. Temperature 32° F. Density 8.90.

Electrical Constants.

Resistance and Conductivity.					
Ohms per Foot.	Log.	Feet per Ohm.	Ohms per Pound.	Pounds per Ohm.	Gauge Number.
0.00004629	$\bar{5}$.66551	21601.	0.00007219	13852.	0000
.00005837	.76622	17131.	.00011479	8712.	000
.00007361	.86693	13586.	.00018253	5479.	00
.00009282	.96764	10774.	.00029023	3445.	0
0.0001170	$\bar{4}$.06834	8544.	0.0004615	2166.8	**1**
.0001476	.16905	6775.	.0007338	1362.8	2
.0001861	.26976	5373.	.0011668	857.0	3
.0002347	.37046	4261.	.0018552	539.0	4
.0002959	.47117	3379.	.0029499	339.0	5
0.0003731	$\bar{4}$.57188	2680.	0.004690	213.22	**6**
.0004705	.67259	2125.	.007458	134.08	7
.0005933	.77329	1685.	.011859	84.32	8
.0007482	.87400	1337.	.018857	53.03	9
.0009434	.97471	1060.	.029984	33.35	10
0.001190	$\bar{3}$.07541	840.6	0.04768	20.973	**11**
.001500	.17612	666.6	.07581	13.191	12
.001892	.27683	528.7	.12054	8.296	13
.002385	.37753	419.2	.19166	5.218	14
.003008	.47824	332.5	.30476	3.281	15
0.003793	$\bar{3}$.57895	263.7	0.4846	2.0636	**16**
.004783	.67966	209.1	.7705	1.2979	17
.006031	.78036	165.8	1.2252	0.8162	18
.007604	.88107	131.5	1.9481	.5133	19
.009589	.98178	104.3	3.0976	.3228	20
0.01209	$\bar{2}$.08248	82.70	4.925	0.20305	**21**
.01525	.18319	65.59	7.832	.12768	22
.01923	.28390	52.01	12.453	.08030	23
.02424	.38461	41.25	19.801	.05051	24
.03057	.48531	32.71	31.484	.03176	25
0.03855	$\bar{2}$.58602	25.94	50.06	0.019976	**26**
.04861	.68673	20.57	79.60	.012563	27
.06130	.78743	16.31	126.57	.007901	28
.07729	.88814	12.94	201.26	.004969	29
.09746	.98885	10.26	320.01	.003125	30
0.1229	$\bar{1}$.08955	8.137	508.8	0.0019654	**31**
.1550	.19026	6.452	809.1	.0012359	32
.1954	.29097	5.117	1286.5	.0007773	33
.2464	.39168	4.058	2045.6	.0004889	34
.3107	.49238	3.218	3252.6	.0003074	35
0.3918	$\bar{1}$.59309	2.552	5172.	0.0001934	**36**
.4941	.69380	2.024	8224.	.0001216	37
.6230	.79450	1.605	13076.	.0000765	38
.7856	.89521	1.273	20792.	.0000481	39
.9906	.99592	1.009	33060.	.0000303	40

TABLE 41.

SIZE, WEIGHT, AND ELECTRICAL

Size, Weight, and Electrical Constants of pure hard drawn Copper Wire of different numbers

Size and Weight.

Gauge Number.	Diameter in Centimetres.	Square of Diameter (Circular Cms.).	Section in Sq. Cms.	Grammes per Metre.	Log.	Metres per Gramme.
0000	1.1684	1.3652	1.0722	954.3	2.97966	0.001048
000	.0405	.0826	0.8503	756.8	.87896	.001322
00	0.9266	0.8586	.6743	600.1	.77825	.001666
0	.8251	.6809	.5348	475.9	.67754	.002101
1	0.7348	0.5400	0.4241	377.4	2.57684	0.002649
2	.6544	.4282	.3363	299.3	.47613	.003341
3	.5827	.3396	.2667	237.4	.37542	.004213
4	.5189	.2693	.2115	188.2	.27472	.005312
5	.4621	.2136	.1677	149.3	.17401	.006699
6	0.4115	0.16936	0.13302	118.39	2.07330	0.00845
7	.3665	.13431	.10549	93.88	1.97259	.01065
8	.3264	.10651	.08366	74.45	.87189	.01343
9	.2906	.08447	.06634	59.04	.77118	.01694
10	.2588	.06699	.05261	46.82	.67047	.02136
11	0.2305	0.05312	0.04172	37.13	1.56977	0.02693
12	.2053	.04213	.03309	29.45	.46906	.03396
13	.1828	.03341	.02624	23.35	.36835	.04282
14	.1628	.02649	.02081	18.52	.26764	.05400
15	.1450	.02101	.01650	14.69	.16694	.06809
16	0.12908	0.016663	0.013087	11.648	1.06623	0.0859
17	.11495	.013214	.010378	9.237	0.96552	.1083
18	.10237	.010479	.008231	7.325	.86482	.1365
19	.09116	.008330	.006527	5.809	.76411	.1721
20	.08118	.006591	.005176	4.607	.66340	.2171
21	0.07229	0.005227	0.004105	3.653	0.56270	0.2737
22	.06438	.004145	.003255	2.898	.46199	.3450
23	.05733	.003287	.002582	2.298	.36128	.4352
24	.05106	.002607	.002047	1.822	.26057	.5488
25	.04545	.002067	.001624	1.445	.15987	.6920
26	0.04049	0.0016394	0.0012876	1.1459	0.05916	0.873
27	.03606	.0013001	.0010211	.9088	$\bar{1}.95845$	1.100
28	.03211	.0010310	.0008098	.7207	.85775	1.388
29	.02859	.0008176	.0006422	.5715	.75704	1.750
30	.02546	.0006484	.0005093	.4532	.65633	2.206
31	0.02268	0.0005142	0.0004039	0.3594	$\bar{1}.55562$	2.782
32	.02019	.0004078	.0003203	.2850	.45492	3.508
33	.01798	.0003234	.0002540	.2261	.35421	4.424
34	.01601	.0002565	.0002014	.1793	.25350	5.578
35	.01426	.0002034	.0001597	.1422	.15280	7.034
36	0.01270	0.0001613	0.0001267	0.1127	$\bar{1}.05209$	8.87
37	.01131	.0001279	.0001005	.0894	$\bar{2}.95138$	11.18
38	.01007	.0001014	.0000797	.0709	.85068	14.10
39	.00897	.0000804	.0000632	.0562	.74997	17.78
40	.00799	.0000638	.0000501	.0446	.64926	22.43

CONSTANTS OF COPPER WIRE.

according to the American Brown and Sharp Gauge. Metric Measure. Temperature 0° C. Density 8.90.

Electrical Constants.

Resistance and Conductivity.					Gauge Number.
Ohms per Metre.	Log.	Metres per Ohm.	Ohms per Gramme.	Grammes per Ohm.	
0.0001519	$\bar{4}$.18150	6584.	0.0000001592	6283000.	0000
.0001915	.28221	5221.	.0000002531	3951000.	000
.0002415	.38191	4141.	.0000004024	2485000.	00
.0003045	.48362	3284.	.0000006398	1563000.	0
0.0003840	$\bar{4}$.58433	2604.	0.000001017	982900.	**1**
.0004842	.68503	2065.	.000001618	618200.	2
.0006106	.78574	1638.	.000002572	388800.	3
.0007699	.88645	1299.	.000004090	244500.	4
.0009709	.98715	1030.	.000006504	153800.	5
0.001224	$\bar{3}$.08786	816.9	0.00001034	96700.	**6**
.001544	.18857	647.8	.00001644	60820.	7
.001947	.28928	513.7	.00002615	38250.	8
.002455	.38998	407.4	.00004157	24050.	9
.003095	.49069	323.1	.00006610	15130.	10
0.003903	$\bar{3}$.59140	256.2	0.00010511	9514.	**11**
.004922	.69210	203.2	.00016712	5984.	12
.006206	.79281	161.1	.00026574	3763.	13
.007826	.89352	127.8	.00042254	2367.	14
.009868	.99423	101.3	.00067187	1488.	13
0.01244	$\bar{2}$.09493	80.37	0.0010683	936.1	**16**
.01569	.19564	63.73	.0016987	588.7	17
.01979	.29635	50.54	.0027010	370.2	18
.02495	.39705	40.08	.0042948	232.8	19
.03146	.49776	31.79	.0068290	146.4	20
0.03967	$\bar{2}$.59847	25.21	0.010859	92.09	**21**
.05002	.69917	19.99	.017266	57.92	22
.06308	.79988	15.85	.027454	36.42	23
.07954	.90059	12.57	.043653	22.91	24
.10030	$\bar{1}$.00130	9.97	.069411	11.88	25
0.12647	$\bar{1}$.10200	7.907	0.11037	9.060	**26**
.15948	.20271	6.270	.17549	5.698	27
.20110	.30342	4.973	.27904	3.584	28
.25358	.40412	3.943	.44369	2.254	29
.31976	.50483	3.127	.70550	1.417	30
0.4032	$\bar{1}$.60554	2.480	1.1218	0.8914	**31**
.5084	.70624	1.967	1.7837	.5606	32
.6411	.80695	1.560	2.8362	.3526	33
.8085	.90766	1.237	4.5097	.2217	34
1.0194	0.00837	0.981	7.1708	.1394	35
1.2855	0.10907	0.7779	11.376	0.08790	**36**
1.6210	.20978	.6169	18.130	.05516	37
2.0440	.31049	.4892	28.828	.03469	38
2.5775	.41119	.3880	45.838	.02182	39
3.2501	.51190	.3076	72.885	.01372	40

WEIGHT OF SHEET METAL.

TABLE 42. — Weight of Sheet Metal. (Metric Measure.)

This table gives the weight in grammes of a plate one metre square and of the thickness stated in the first column.

Thickness in thousandths of a cm.	Iron.	Copper.	Brass.	Aluminum.	Platinum.	Gold.	Silver.
1	78.0	89.0	85.6	26.7	215.0	193.0	105.0
2	156.0	178.0	171.2	53.4	430.0	386.0	210.0
3	234.0	267.0	256.8	80.1	645.0	579.0	315.0
4	312.0	356.0	342.4	106.8	860.0	772.0	420.0
5	390.0	445.0	428.0	133.5	1075.0	965.0	525.0
6	468.0	534.0	513.6	160.2	1290.0	1158.0	630.0
7	546.0	623.0	599.2	186.9	1505.0	1351.0	735.0
8	624.0	712.0	684.8	213.6	1720.0	1544.0	840.0
9	702.0	801.0	770.4	240.3	1935.0	1737.0	945.0
10	780.0	890.0	856.0	267.0	2150.0	1930.0	1050.0

TABLE 43. — Weight of Sheet Metal. (British Measure.)

Thickness in Mils.	Iron.	Copper.	Brass.	Aluminum.		Platinum.	
	Pounds per Sq. Foot.	Pounds per Sq. Foot.	Pounds per Sq. Foot.	Pounds per Sq. Foot.	Ounces per Sq. Foot.	Pounds per Sq. Foot.	Ounces per Sq. Foot.
1	.04058	.04630	.04454	.01389	.2222	.1119	1.790
2	.08116	.09260	.08908	.02778	.4445	.2237	3.579
3	.12173	.13890	.13363	.04167	.6667	.3356	5.369
4	.16231	.18520	.17817	.05556	.8890	.4474	7.158
5	.20289	.23150	.22271	.06945	1.1112	.5593	8.948
6	.24347	.27780	.26725	.08334	1.3335	.6711	10.738
7	.28405	.32411	.31179	.09723	1.5557	.7830	12.527
8	.32463	.37041	.35634	.11112	1.7780	.8948	14.317
9	.36520	.41671	.40088	.12501	2.0002	1.0067	16.106
10	.40578	.46301	.44542	.13890	2.2224	1.1185	17.896

Thickness in Mils.	Gold.		Silver.	
	Troy Ounces per Sq. Foot.	Grains per Sq. Foot.	Troy Ounces per Sq. Foot.	Grains per Sq. Foot.
1	1.4642	702.8	0.7967	382.4
2	2.9285	1405.7	1.5933	764.8
3	4.3927	2108.5	2.3900	1147.2
4	5.8570	2811.3	3.1867	1529.6
5	7.3212	3514.2	3.9833	1912.0
6	8.7854	4217.0	4.7800	2294.4
7	10.2497	4919.8	5.5767	2676.8
8	11.7139	5622.7	6.3734	3059.2
9	13.1782	6325.5	7.1700	3441.6
10	14.6424	7028.3	7.9667	3824.0

TABLE 44.

STRENGTH OF MATERIALS.

The strength of most materials varies so that the following figures serve only as a rough indication of the strength of a particular sample.

TABLE 44 (a). — Metals.

Name of Metal.	Tensile strength in pounds per sq. in.
Aluminum wire	30000–40000
Brass wire	50000–150000
Bronze wire, phosphor, hard-drawn	110000–140000
Bronze wire, silicon, hard-drawn	95000–115000
Bronze: Cu, 58.54 parts; Zn, 38.70; Al, 0.21; with 2.55 parts of the alloy, Sn, 29.03, wrought iron, 58.06, ferro-manganese, 12.91	60000–75000
Copper wire, hard-drawn	60000–70000
Gold wire	20000
Iron, cast	13000–33000
" wire, hard-drawn	80000–120000
" " annealed	50000–60000
Lead, cast or drawn	2600–3300
Palladium *	39000
Platinum * wire	50000
Silver * wire	42000
Steel	80000–330000
" wire, maximum	460000
" Specially treated nickel-steel, approx. comp. 0.40 C; 3.25 Ni; treatment secret	250000
" piano wire, 0.033 in. diam.	357000–390000
" piano wire, 0.051 in. diam.	325000–337000
Tin, cast or drawn	4000–5000
Zinc, cast	7000–13000
" drawn	22000–30000

According to Boys, quartz fibres have a tensile strength of between 116000 and 167000 pounds per square inch.

* Authority of Wertheim.

TABLE 44 (b). — Stones.*

Material.	Size of test piece.	Resistance to crushing in pds. per sq. in.
Marble	4 in. cubes	7600–20700
Tufa	2 " "	7700–11600
Brownstone	– – –	7300–23600
Sandstone	4 in. cubes	2400–29300
Granite	4 " "	9700–34000
Limestone	4 " "	6000–25000

* Data furnished by the U. S. Geological Survey.

TABLE 44 (c). — Brick.*

Kind of Brick.	Resistance to crushing in pds. per sq. in.	
	Tested flatwise.	Tested on edge.
Soft burned	1800–4000	1600–3000
Medium burned	4000–6000	3000–4500
Hard burned	6000–8500	4500–6500
Vitrified	8500–25000	6500–20000
Sand-lime	1800–4000	

Brick piers laid up in 1 part Portland cement, 3 of sand, have from 20 to 40 per cent the crushing strength of the brick.

* Data furnished by the U. S. Geological Survey.

TABLE 44 (d). — Concretes.*

Coarse material. "Aggregate."	Proportions by volume. Cement: sand: aggregate.	Size of test piece.	Resistance to crushing in pds. per sq. in.
Sandstone	1 : 5 : 14 to 1 : 1 : 5	12 in. cube	1550–3860
Cinders	1 : 3 : 6 " 1 : 1 : 3	12 " "	790–2050
Limestone	1 : 4 : 8 " 1 : 2 : 4	12 " "	1200–2840
Conglomerate	1 : 6 : 12 " 1 : 2 : 4	12 " "	1080–3830
Trap	1 : 2 : 9 " 1 : 2 : 4	12 " "	820–2960

* Data furnished by the U. S. Geological Survey.

TABLE 45.

STRENGTH OF MATERIALS.

Average Results of Timber Tests.

The test pieces were SMALL and SELECTED. Endwise compression tests of some of the first lot, made when green and containing over 40 per cent moisture, showed a diminishing in strength of 50 to 75 per cent.

See also Table 46. A particular sample may vary greatly from these data, which can indicate only in a general way the relative values of a kind of timber. Note that the data below are from selected samples and therefore probably high.

The upper lot are from the U. S. Forestry circular No. 15; the lower from the tests made for the 10th U. S. Census.

NAME OF SPECIES.	TRANSVERSE TESTS.		COMPRESSION.		SHEARING.
	Modulus of rupture. lb./sq. in.	Modulus of elasticity. lbs./sq. in.	∥ to grain. lbs./sq. in.	⊥ to grain. lbs./sq. in.	Along the grain. lbs./sq. in.
Long-leaf pine	12,600	2,070,000	8,000	1260	835
Cuban pine	13,600	2,370,000	8,700	1200	770
Short-leaf pine	10,100	1,680,000	6,500	1050	770
Loblolly pine	11,300	2,050,000	7,400	1150	800
White pine	7,900	1,390,000	5,400	700	400
Red pine	9,100	1,620,000	6,700	1000	500
Spruce pine	10,000	1,640,000	7,300	1200	800
Bald cypress	7,900	1,290,000	6,000	800	500
White cedar	6,300	910,000	5,200	700	400
Douglass spruce	7,900	1,680,000	5,700	800	500
White oak	13,100	2,090,000	8,500	2200	1000
Overcup oak	11,300	1,620,000	7,300	1900	1000
Post oak	12,300	2,030,000	7,100	3000	1100
Cow oak	11,500	1,610,000	7,400	1900	900
Red oak	11,400	1,970,000	7,200	2300	1100
Texan oak	13,100	1,860,000	8,100	2000	900
Yellow oak	10,800	1,740,000	7,300	1800	1100
Water oak	12,400	2,000,000	7,800	2000	1100
Willow oak	10,400	1,750,000	7,200	1600	900
Spanish oak	12,000	1,930,000	7,700	1800	900
Shagbark hickory	16,000	2,390,000	9,500	2700	1100
Mockernut hickory	15,200	2,320,000	10,100	3100	1100
Water hickory	12,500	2,080,000	8,400	2400	1000
Bitternut hickory	15,000	2,280,000	9,600	2200	1000
Nutmeg hickory	12,500	1,940,000	8,800	2700	1100
Pecan hickory	15,300	2,530,000	9,100	2800	1200
Pignut hickory	18,700	2,730,000	10,900	3200	1200
White elm	10,300	1,540,000	6,500	1200	800
Cedar elm	13,500	1,700,000	8,000	2100	1300
White ash	10,800	1,640,000	7,200	1900	1100
Green ash	11,600	2,050,000	8,000	1700	1000
Sweet gum	9,500	1,700,000	7,100	1400	800
Poplar	9,400	1,330,000	5,000	1120	
Basswood	8,340	1,172,000	5,190	880	
Ironwood	7,540	1,158,000	5,275	2000	
Sugar maple	16,500	2,250,000	8,800	3600	
White maple	14,640	1,800,000	6,850	2580	
Box elder	7,580	873,000	4,580	1580	
Black walnut	11,900	1,560,000	8,000	2680	
Sycamore	7,000	790,000	6,400	2700	
Hemlock	9,480	1,138,000	5,400	1100	
Red fir	13,270	1,870,000	7,780	1750	
Tamarack	13,150	1,917,000	7,400	1480	
Red cedar	11,800	938,000	6,300	2000	
Cottonwood	10,440	1,450,000	5,000	1100	
Beech	16,200	1,730,000	6,770	2840	

TABLE 46.

UNIT STRESSES FOR STRUCTURAL TIMBER EXPRESSED IN POUNDS PER SQUARE INCH.

Recommended by the Committee on Wooden Bridges and Trestles, American Railway Engineering Association, 1909.

KIND OF TIMBER.	BENDING.			SHEARING.			
	Extreme fibre stress.		Modulus of elasticity.	Parallel to grain.		Longitudinal shear in beams.	
	Average ultimate.	Safe stress.	Average.	Average ultimate.	Safe stress.	Average ultimate.	Safe stress.
Douglass fir	6100	1200	1,510,000	690	170	270	110
Long-leaf pine	6500	1300	1,610,000	720	180	300	120
Short-leaf pine	5600	1100	1,480,000	710	170	336	130
White pine	4400	900	1,130,000	400	100	180	70
Spruce	4800	1000	1,310,000	600	150	170	70
Norway pine	4200	800	1,190,000	590	130	250	100
Tamarack	4600	900	1,220,000	670	170	260	100
Western hemlock	5800	1100	1,480,000	630	160	270*	100
Redwood	5000	900	800,000	300	80	–	–
Bald cypress	4800	900	1,150,000	500	120	–	–
Red cedar	4200	800	860,000	–	–	–	–
White oak	5700	1100	1,150,000	840	210	270	110

KIND OF TIMBER.	COMPRESSION.						Ratio of length of stringer to depth.
	Perpendicular to grain.		Parallel to grain.		For columns under 15 diams. Safe stress.	Formulas for safe stress in long columns over 15 diameters.†	
	Elastic limit.	Safe stress.	Average ultimate.	Safe stress.			
Douglass fir	630	310	3600	1200	900	1200(1–L/60.D)	10
Long-leaf pine	520	260	3800	1300	980	1300(1–L/60.D)	10
Short-leaf pine	340	170	3400	1100	830	1100(1–L/60.D)	10
White pine	290	150	3000	1000	750	1000(1–L/60.D)	10
Spruce	370	180	3200	1100	830	1100(1–L/60.D)	–
Norway pine	–	150	2600*	800	600	800(1–L/60.D)	–
Tamarack	–	220	3200*	1000	750	1000(1–L/60.D)	–
Western hemlock	440	220	3500	1200	900	1200(1–L/60.D)	–
Redwood	400	150	3300	900	680	900(1–L/60.D)	–
Bald cypress	340	170	3900	1100	830	1100(1–L/60.D)	–
Red cedar	470	230	2800	900	680	900(1–L/60.D)	–
White oak	920	450	3500	1300	980	1300(1–L/60.D)	12

These unit stresses are for a green condition of the timber and are to be used without increasing the live-load stresses for impact.

* Partially air-dry.

† L = length in inches. D = least side in inches.

ELASTIC MODULI.

TABLE 47. — Rigidity Modulus.

If to the four consecutive faces of a cube a tangential stress is applied, opposite in direction on adjacent sides, the modulus of rigidity is obtained by dividing the numerical value of the tangential stress per unit area (kg. per sq. mm.) by the number representing the change of angles on the non-stressed faces, measured in radians.

Substance.	Rigidity Modulus.	Reference.	Substance.	Rigidity Modulus.	Reference.
Aluminum	3350	14	Quartz fibre	2888	20
" cast	2580	5	" "	2380	21
Brass	3550	10	Silver	2960	5
"	3715	11	"	2650	10
" cast, 60 Cu + 12 Sn	3700	5	"	2566	16
Bismuth, slowly cooled	1240	5	" hard-drawn	2816	11
Bronze, cast, 88 Cu + 12 Sn	4060	5	Steel	8290	16
Cadmium, cast	2450	5	" cast	7458	15
Copper, cast	4780	5	" cast, coarse gr.	8070	5
"	4213	18	" silver-	7872	11
"	4450	10	Tin, cast	1730	5
"	4664	19	"	1543	19
Gold	2850	5	Zinc	3880	5
"	3950	14	"	3820	19
Iron, cast	5210	5	Platinum	6630	16
"	6706	15	"	6220	22
"	7975	10	Glass	2350	–
"	6940	7	"	2730	–
"	8108	16	Clay rock	1770	23
"	7505	14	Granite	1280	23
Magnesium, cast	1710	5	Marble	1190	23
Nickel	7820	5	Slate	2290	23
Phosphor bronze	4359	11			

References 1–16, see Table 48.
17 Grätz, Wied. Ann. 28, 1886.
18 Savart, Pogg. Ann. 16, 1829.
19 Kiewiet, Diss. Göttingen, 1886.
20 Threlfall, Philos. Mag. (5) 30, 1890.
21 Boys, Philos. Mag. (5) 30, 1890.
22 Thomson, Lord Kelvin.
23 Gray and Milne.
24 Adams-Coker, Carnegie Publ. No. 46, 1906.

TABLE 47a. — Variation of the Rigidity Modulus with the Temperature.

$n_t = n_o (1 - \alpha t - \beta t^2 - \gamma t^3)$, where t = temperature Centigrade.

Substance.	n_o	$\alpha 10^5$	$\beta 10^8$	$\gamma 10^{10}$	Authority.
Brass	2652	2158	48	32	Pisati, Nuovo Cimento, 5, 34, 1879.
"	3200	455	36	–	Kohlrausch-Loomis, Pogg. Ann. 141.
Copper	3972	2716	—23	47	Pisati, loc. cit.
"	3900	572	28	–	K and L, loc. cit.
Iron	8108	206	19	—11	Pisati, loc. cit.
"	6940	483	12	–	K and L, loc. cit.
Platinum	6632	111	50	—8	Pisati, loc. cit.
Silver	2566	387	38	11	" " "
Steel	8290	187	59	—9	" " "

$n_t^* = n_{15} [1 - \alpha (t - 15)]$; Horton, Philos. Trans. 204 A, 1905.

Copper	4.37*	α = .00039	Platinum	6.46*	α = .00012	Tin	1.50*	α = .00416
Copper (commercial)	3.80	.00038	Gold	2.45	.00031	Lead	0.80	.00164
Iron	8.26	.00029	Silver	2.67	.00048	Cadmium	2.31	.0058
Steel	8.45	.00026	Aluminum	2.55	.00148	Quartz	3.00	.00012

* Modulus of rigidity in 10^{11} dynes per sq. cm.

TABLE 48.

ELASTIC MODULI.

Young's Modulus.

$$\text{Young's Modulus} = \frac{\text{Intensity of longitudinal stress (kg. per sq. mm.)}}{\text{Elongation per unit length}}.$$

Substance.	Temp. °C.	Young's Modulus.	Reference.
Aluminum	20	7200	1
"	12.3	7462	2
Lead, drawn	15	1803	3
" annealed . . .	15	1727	3
Bronze	–	9194	4
Cadmium	–	7070	5
Delta metal	–	11697	6
Iron, drawn	15	20869	3
" annealed . . .	15	20794	3
"	0	20310	7
"	–	21740	8
" cast	–	11713	4
" soft	15.6	15750	9
" drawn	20	19385	1
" drawn	–	20500	10
Gold, drawn	15	8131	3
" annealed . . .	15	5585	3
" drawn	12.9	8630	2
Copper, drawn . . .	15	12450	3
" annealed . .	15	10520	3
" drawn . . .	0	12140	7
" drawn . . .	20	12550	1
" electr. h'd d'n	19.5	13220	9
Brass, drawn	15	8543	3
"	0	9810	7
" drawn	–	10220	11
"	–	9930	10
"	–	10450	9
German silver . . .	–	12094	4
" " h'd d'n	–	11550	11
" " . . .	20	13300	9
Nickel	–	20300	5
"	–	22790	12
" hard drawn . .	–	23950	11
"	11.5	21680	2

Substance.	Temp. °C.	Young's Modulus.	Reference.
Nickel-steel, 5½% ni. .	–	19900	13
" " 25% " .	–	18600	13
Palladium, annealed .	15	9709	3
Phosphor-bronze . .	–	12010	11
Platinum, drawn . .	15	17044	3
" annealed .	15	15518	3
"	13.2	16020	2
" drawn . .	10	15989	1
Silver, drawn	15	7357	3
" annealed . .	15	7140	3
Steel wire, drawn . .	15	18810	3
" " annealed .	15	17280	3
Steel, cast, drawn . .	15	19550	3
" " annealed .	15	19560	3
" Bessemer . . .	-	21136	4
" puddle	–	21112	4
" mild	15.5	21700	9
" very soft . . .	–	20705	13
" half soft . . .	–	20910	13
" hard	–	20600	13
Bismuth	–	3190	5
Zinc, drawn	15	8734	3
Tin, drawn	15	4148	3
" cast	–	1700	13
Glass	–	6000 to 8000	–
Carbon	–	1500 to 2500	–
Marbles	–	6316	24
Granites	–	5159	24
Basic intrusives . . .	–	8985	24
Rocks: See Nagaoka, Philos. Mag. 1900.			

1 Slotte, Acta Soc. Fenn. 26, 1899; 29, 1900.
2 Meyer, Wied. Ann. 59, 1896.
3 Wertheim, Ann. chim. phys. (3) 12, 1844.
4 Pscheidl, Wien. Ber. II, 79, 1879.
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6 Amagat, C. R. 108, 1889.
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8 Thomas, Drude Ann. 1, 1900.
9 Gray, etc., Proc. Roy. Soc. 67, 1900.
10 Baumeister, Wied. Ann. 18, 1883.
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12 Cantone, Wied. Beibl. 14, 1890.
13 Mercadier, C. R. 113, 1891.
14 Katzenelsohn, Diss. Berlin, 1887.
15 Wertheim, Pogg. Ann. 78, 1849.
16 Pisati, Nuovo Cimento, 5, 34, 1879.
References 17–19, see Table 47.

Compiled partly from Landolt-Börnstein's Physikalisch-Chemische Tabellen.

COMPRESSIBILITY, HARDNESS, CONTRACTION OF ELEMENTS.

TABLE 49. — Compressibility of the More Important Solid Elements.

Arranged in order of the increasing atomic weights. The numbers give the mean elastic change of volume for one megabar (0.987 atm.) between 100 and 500 megabars, multiplied by 10^6.

Lithium	8.8	Potassium	31.5	Selenium	11.8	Iodine	13.
Carbon	0.5	Calcium	5.5	Bromine	51.8	Cæsium	61.
Sodium	15.4	Chromium	0.7	Rubidium	40.	Platinum	0.21
Magnesium	2.7	Manganese	0.7	Molybdium	0.26	Gold	0.47
Aluminum	1.3	Iron	0.40	Palladium	0.38	Mercury	3.71
Silicon	0.16	Nickel	0.27	Silver	0.84	Thallium	2.6
Red phosphorus	9.0	Copper	0.54	Cadmium	1.9	Lead	2.2
Sulphur	12.5	Zinc	1.5	Tin	1.6	Bismuth	2.8
Chlorine	95.	Arsenic	4.3	Antimony	2.2		

Stull, Zeitschr. Phys. Chem. 61, 1907.

TABLE 50.— Hardness.

Agate	7.	Brass	3–4.	Iridosmium	7.	Sulphur	1.5–2.5
Alabaster	1.7	Calimine	5.	Iron	4–5.	Stibnite	2.
Alum	2–2.5	Calcite	3.	Kaolin	1.	Serpentine	3–4.
Aluminum	2.	Copper	2.5–3.	Loess (0°)	0.3	Silver	2.5–3.
Amber	2–2.5	Corundum	9.	Magnetite	6.	Steel	5–8.5
Andalusite	7.5	Diamond	10.	Marble	3–4.	Talc	1.
Anthracite	2.2	Dolomite	3.5–4.	Meerschaum	2–3.	Tin	1.5
Antimony	3.3	Feldspar	6.	Mica	2.8	Topaz	8.
Apatite	5.	Flint	7.	Opal	4–6.	Tourmaline	7.3
Aragonite	3.5	Fluorite	4.	Orthoclase	6.	Wax (0°)	0.2
Arsenic	3.5	Galena	2.5	Palladium	4.8	Wood's metal	3.
Asbestos	5.	Garnet	7.	Phosphorbronze	4.		
Asphalt	1–2.	Glass	4.5–6.5	Platinum	4.3		
Augite	6.	Gold	2.5–3.	Plat-iridium	6.5		
Barite	3.3	Graphite	0.5–1.	Pyrite	6.3		
Beryl	7.8	Gypsum	1.6–2.	Quartz	7.		
Bell-metal	4.	Hematite	6.	Rock-salt	2.		
Bismuth	2.5	Hornblende	5.5	Ross' metal	2.5–3.0		
Boric acid	3.	Iridium	6.	Silver chloride	1.3		

From Landolt-Börnstein-Meyerhoffer Tables: Auerbachs, Winklemann, Handb. der Phys. 1891.

TABLE 51.—Relative Hardness of the Elements.

C	10.0	Ru	6.5	Cu	3.0	Au	2.5	Sn	1.8	Li	0.6
B	9.5	Mn	5.0	Sb	3.0	Te	2.3	Sr	1.8	P	0.5
Cr	9.0	Pd	4.8	Al	2.9	Cd	2.0	Ca	1.5	K	0.5
Os	7.0	Fe	4.5	Ag	2.7	S	2.0	Ga	1.5	Na	0.4
Si	7.0	Pt	4.3	Bi	2.5	Se	2.0	Pb	1.5	Rb	0.3
Ir	6.5	As	3.5	Zn	2.5	Mg	2.0	In	1.2	Cs	0.2

Rydberg, Zeitschr. Phys. Chem. 33, 1900.

TABLE 52.— Ratio, ρ, of Transverse Contraction to Longitudinal Extension under Tensile Stress.

(Poisson's Ratio.)

Metal	Pb	Au	Pd	Pt	Ag	Cu	Al	Bi	Sn	Ni	Cd	Fe
ρ	0.45	0.42	0.39	0.39	0.38	0.35	0.34	0.33	0.33	0.31	0.30	0.28

From data from Physikalisch-Technischen Reichsanstalt, 1907.

ρ for: marbles, 0.27; granites, 0.24; basic-intrusives, 0.26; glass, 0.23. Adams-Coker, 1906.

TABLE 53.

ELASTICITY OF CRYSTALS.*

The formulæ were deduced from experiments made on rectangular prismatic bars cut from the crystal. These bars were subjected to cross bending and twisting and the corresponding Elastic Moduli deduced. The symbols $\alpha\ \beta\ \gamma$, $\alpha_1\ \beta_1\ \gamma_1$ and $\alpha_2\ \beta_2\ \gamma_2$ represent the direction cosines of the length, the greater and the less transverse dimensions of the prism with reference to the principal axis of the crystal. E is the modulus for extension or compression, and T is the modulus for torsional rigidity. The moduli are in grammes per square centimetre.

Barite.

$$\frac{10^{10}}{E} = 16.13\alpha^4 + 18.51\beta^4 + 10.42\gamma^4 + 2(38.79\beta^2\gamma^2 + 15.21\gamma^2\alpha^2 + 8.88\alpha^2\beta^2)$$

$$\frac{10^{10}}{T} = 69.52\alpha^4 + 117.66\beta^4 + 116.46\gamma^4 + 2(20.16\beta^2\gamma^2 + 85.29\gamma^2\alpha^2 + 127.35\alpha^2\beta^2)$$

Beryl (Emerald).

$$\left.\begin{aligned}\frac{10^{10}}{E} &= 4.325\sin^4\phi + 4.619\cos^4\phi + 13.328\sin^2\phi\cos^2\phi \\ \frac{10^{10}}{T} &= 15.00 - 3.675\cos^4\phi_2 - 17.536\cos^2\phi\cos^2\phi_1\end{aligned}\right\{$$

where $\phi\,\phi_1\,\phi_2$ are the angles which the length, breadth, and thickness of the specimen make with the principal axis of the crystal.

Fluor spar.

$$\frac{10^{10}}{E} = 13.05 - 6.26(\alpha^4 + \beta^4 + \gamma^4)$$

$$\frac{10^{10}}{T} = 58.04 - 50.08(\beta^2\gamma^2 + \gamma^2\alpha^2 + \alpha^2\beta^2)$$

Pyrites.

$$\frac{10^{10}}{E} = 5.08 - 2.24(\alpha^4 + \beta^4 + \gamma^4)$$

$$\frac{10^{10}}{T} = 18.60 - 17.95(\beta^2\gamma^2 + \gamma^2\alpha^2 + \alpha^2\beta^2)$$

Rock salt.

$$\frac{10^{10}}{E} = 33.48 - 9.66(\alpha^4 + \beta^4 + \gamma^4)$$

$$\frac{10^{10}}{T} = 154.58 - 77.28(\beta^2\gamma^2 + \gamma^2\alpha^2 + \alpha^2\beta^2)$$

Sylvine.

$$\frac{10^{10}}{E} = 75.1 - 48.2(\alpha^4 + \beta^4 + \gamma^4)$$

$$\frac{10^{10}}{T} = 306.0 - 192.8(\beta^2\gamma^2 + \gamma^2\alpha^2 + \alpha^2\beta^2)$$

Topaz.

$$\frac{10^{10}}{E} = 4.341\alpha^4 + 3.460\beta^4 + 3.771\gamma^4 + 2(3.879\beta^2\gamma^2 + 2.856\gamma^2\alpha^2 + 2.39\alpha^2\beta^2)$$

$$\frac{10^{10}}{T} = 14.88\alpha^4 + 16.54\beta^4 + 16.45\gamma^4 + 30.89\beta^2\gamma^2 + 40.89\gamma^2\alpha^2 + 43.51\alpha^2\beta^2$$

Quartz.

$$\frac{10^{10}}{E} = 12.734(1 - \gamma^2)^2 + 16.693(1 - \gamma^2)\gamma^2 + 9.705\gamma^4 - 8.460\beta\gamma(3\alpha^2 - \beta^2)$$

$$\frac{10^{10}}{T} = 19.665 + 9.060\gamma_2^2 + 22.984\gamma^2\gamma_1^2 - 16.920[(\gamma\beta_1 + \beta\gamma_1)(3\alpha\alpha_1 - \beta\beta_1) - \beta_2\gamma_2)]$$

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* These formulæ are taken from Voigt's papers (Wied. Ann. vols. 31, 34, and 35).

TABLE 54.

ELASTICITY OF CRYSTALS.

Some particular values of the Elastic Moduli are here given. Under E are given moduli for extension or compression in the directions indicated by the subscripts and explained in the notes, and under T the moduli for torsional rigidities round the axes similarly indicated.

(*a*) REGULAR SYSTEM.*

Substance.	E_a	E_b	E_c	T_a	Authority.
Fluor spar . . .	1473×10^6	1008×10^6	910×10^6	345×10^6	Voigt.†
Pyrites	3530×10^6	2530×10^6	2310×10^6	1075×10^6	"
Rock salt	419×10^6	349×10^6	303×10^6	129×10^6	"
"	403×10^6	339×10^6	—	—	Koch.‡
Sylvine	401×10^6	209×10^6	—	—	"
"	372×10^6	196×10^6	—	655×10^6	Voigt.
Sodium chloride .	405×10^6	319×10^6	—	—	Koch.
Potash alum . . .	181×10^6	199×10^6	—	—	Beckenkamp.§
Chrome alum . .	161×10^6	177×10^6	—	—	"
Iron alum	186×10^6	—	—	—	"

(*b*) RHOMBIC SYSTEM.‖

Substance.	E_1	E_2	E_3	E_4	E_5	E_6	Authority.
Barite .	620×10^6	540×10^6	959×10^6	376×10^6	702×10^6	740×10^6	Voigt.
Topaz .	2304×10^6	2890×10^6	2652×10^6	2670×10^6	2893×10^6	3180×10^6	"

Substance.	$T_{12} = T_{21}$	$T_{13} = T_{31}$	$T_{23} = T_{33}$	Authority.
Barite	283×10^6	293×10^6	121×10^6	Voigt.
Topaz	1336×10^6	1353×10^6	1104×10^6	"

In the MONOCLINIC SYSTEM, Coromilas (Zeit. für Kryst. vol. 1) gives

Gypsum $\begin{cases} E_{max} = 887 \times 10^6 \text{ at } 21.9^\circ \text{ to the principal axis.} \\ E_{min} = 313 \times 10^6 \text{ at } 75.4^\circ \quad " \quad " \quad " \end{cases}$

Mica $\begin{cases} E_{max} = 2213 \times 10^6 \text{ in the principal axis.} \\ E_{min} = 1554 \times 10^6 \text{ at } 45^\circ \text{ to the principal axis.} \end{cases}$

In the HEXAGONAL SYSTEM, Voigt gives measurements on a beryl crystal (emerald). The subscripts indicate inclination in degrees of the axis of stress to the principal axis of the crystal.

$E_0 = 2165 \times 10^6$, $E_{45} = 1796 \times 10^6$, $E_{90} = 2312 \times 10^6$,
$T_0 = 667 \times 10^6$, $T_{90} = 883 \times 10^6$. The smallest cross dimension of the prism experimented on (see Table 82), was in the principal axis for this last case.

In the RHOMBOHEDRIC SYSTEM, Voigt has measured quartz. The subscripts have the same meaning as in the hexagonal system.

$E_0 = 1030 \times 10^6$, $E_{-45} = 1305 \times 10^6$, $E_{+45} = 850 \times 10^6$, $E_{90} = 785 \times 10^6$,
$T_0 = 508 \times 10^6$, $T_{90} = 348 \times 10^6$.

Baumgarten ¶ gives for calcspar

$E_0 = 501 \times 10^6$, $E_{-45} = 441 \times 10^6$, $E_{+45} = 772 \times 10^6$, $E_{90} = 790 \times 10^6$.

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* In this system the subscript *a* indicates that compression or extension takes place along the crystalline axis, and distortion round the axis. The subscripts *b* and *c* correspond to directions equally inclined to two and normal to the third and equally inclined to all three axes respectively.

† Voigt, "Wied. Ann." vol. 31, 34-35; 36, 642.

‡ Koch, "Wied. Ann." vol. 18.

§ Beckenkamp, "Zeit. für Kryst." vol. 10.

‖ The subscripts 1, 2, 3 indicate that the three principal axes are the axes of stress; 4, 5, 6 that the axes of stress are in the three principal planes at angles of 45° to the corresponding axes.

¶ Baumgarten, "Pogg. Ann." vol. 152.

COMPRESSIBILITY OF GASES.

TABLE 55. — Relative Volumes at Various Pressures and Temperatures, the volume at 0° C and at 1 atmosphere being taken as 1 000 000.

Atm.	Oxygen.			Air.			Nitrogen.			Hydrogen.		
	0°	99°.5	199°.5	0°	99°.4	200°.4	0°	99°.5	199°.6	0°	99°.3	200°.5
100	9265	–	–	9730	–	–	9910	–	–	–	–	–
200	4570	7000	9095	5050	7360	9430	5195	7445	9532	5690	7567	9420
300	3208	4843	6283	3658	5170	6622	3786	5301	6715	4030	5286	6520
400	2629	3830	4900	3036	4170	5240	3142	4265	5331	3207	4147	5075
500	2312	3244	4100	2680	3565	4422	2780	3655	4515	2713	3462	4210
600	2115	2867	3570	2450	3180	3883	2543	3258	3973	2387	3006	3627
700	1979	2610	3202	2288	2904	3502	2374	2980	3589	2149	2680	3212
800	1879	2417	2929	2168	2699	3219	2240	2775	3300	1972	2444	2900
900	1800	2268	2718	2070	2544	3000	2149	2616	3085	1832	2244	2657
1000	1735	2151	–	1992	2415	2828	2068	–	–	1720	2093	–

Amagat: C. R. 111, 1890; Ann. chim. phys. (6) 29, 1893.

TABLE 56. — Ethylene.

pv at 0° C and 1 atm. = 1.

Atm.	0°	10°	20°	30°	40°	60°	80°	100°	137°.5	198°.5
46	–	0.562	0.684	–	–	–	–	–	–	–
48	–	0.508	–	–	–	–	–	–	–	–
50	0.176	0.420	0.629	0.731	0.814	0.954	1.077	1.192	1.374	1.652
52	–	0.240	0.598	–	–	–	–	–	–	–
54	–	0.229	0.561	–	–	–	–	–	–	–
56	–	0.227	0.524	–	–	–	–	–	–	–
100	0.310	0.331	0.360	0.403	0.471	0.668	0.847	1.005	1.247	1.580
150	0.441	0.459	0.485	0.515	0.551	0.649	0.776	0.924	1.178	1.540
200	0.565	0.585	0.610	0.638	0.669	0.744	0.838	0.946	1.174	1.537
300	0.806	0.827	0.852	0.878	0.908	0.972	1.048	1.133	1.310	1.628
500	1.256	1.280	1.308	1.337	1.367	1.431	1.500	1.578	1.721	1.985
1000	2.289	2.321	2.354	2.387	2.422	2.493	2.566	2.643	2.798	–

Amagat, C. R. 111, 1890; 116, 1893.

TABLE 57. — Ethylene.

Pressure in metres of mercury.	Relative values of pv at —									
	16°.3	20°.3	30°.1	40°.0	50°.0	60°.0	70°.0	79°.9	89°.9	100°.0
30	1950	2055	2220	2410	2580	2715	2865	2970	3090	3225
60	810	900	1190	1535	1875	2100	2310	2500	2680	2860
90	1065	1115	1195	1325	1510	1710	1930	2160	2375	2565
120	1325	1370	1440	1540	1660	1780	1950	2115	2305	2470
150	1590	1625	1690	1785	1880	1990	2125	2250	2390	2540
180	1855	1890	1945	2035	2130	2225	2340	2450	2565	2700
210	2110	2145	2200	2285	2375	2470	2565	2680	2790	2910
240	2360	2395	2450	2540	2625	2720	2810	2910	3015	3125
270	2610	2640	2710	2790	2875	2965	3060	3150	3240	3345
300	2860	2890	2960	3040	3125	3215	3300	3380	3470	3560
320	3035	3065	3125	3200	3285	3375	3470	3545	3625	3710

Amagat, Ann. chim. phys. (6) 22, 1881.

COMPRESSIBILITY OF GASES.

TABLE 58. — Carbon Dioxide.

Pressure in metres of mercury.	Relative values of pv at —								
	18°.2	35°.1	40°.2	50°.0	60°.0	70°.0	80°.0	90°.0	100°.0
30	liquid	2360	2460	2590	2730	2870	2995	3120	3225
50	–	1725	1900	2145	2330	2525	2685	2845	2980
80	625	750	825	1200	1650	1975	2225	2440	2635
110	825	930	980	1090	1275	1550	1845	2105	2325
140	1020	1120	1175	1250	1360	1525	1715	1950	2160
170	1210	1310	1360	1430	1520	1645	1780	1975	2135
200	1405	1500	1550	1615	1705	1810	1930	2075	2215
230	1590	1690	1730	1800	1890	1990	2090	2210	2340
260	1770	1870	1920	1985	2070	2166	2265	2375	2490
290	1950	2060	2100	2170	2260	2340	2440	2550	2655
320	2135	2240	2280	2360	2440	2525	2620	2725	2830

Atm.	Relative values of pv ; pv at 0° C. and 1 atm. = 1.										
	0°	10°	20°	30°	40°	60°	80°	100°	137°	198°	258°
50	0.105	0.114	0.680	0.775	0.750	0.984	1.096	1.206	1.380	–	–
100	0.202	0.213	0.229	0.255	0.309	0.661	0.873	1.030	1.259	1.582	1.847
150	0.295	0.309	0.326	0.346	0.377	0.485	0.681	0.878	1.159	1.530	1.818
300	0.559	0.578	0.599	0.623	0.649	0.710	0.790	0.890	1.108	1.493	1.820
500	0.891	0.913	0.938	0.963	0.990	1.054	1.124	1.201	1.362	1.678	–
1000	1.656	1.685	1.716	1.748	1.780	1.848	1.921	1.999	–	–	–

Amagat, C. R. 111, 1890; Ann chim. phys. (6) 29, 1893; 22, 1881.

TABLE 59. — Compressibility of Gases.

Gas.	$\frac{p.v. (\frac{1}{2} \text{ atm.})}{p_0v_0 (1 \text{ atm.})}$.	$\frac{1}{p.v.} \frac{d(p.v.)}{dp} = a$.	t	$\underset{t = 0}{a}$	Density. O = 32, 0°C. P = 76cm	Density. Very small pressure.
O_2	1.00038	— .00076	11.2°	— .00094	32.	32.
H_2	0.99974	+ .00052	10.7	+ .00053	2.015 (16°)	2.0173
N_2	1.00015	— .00030	14.9	— .00056	28.005	28.016
CO	1.00026	— .00052	13.8	— .00081	28.000	28.003
CO_2	1.00279	— .00558	15.0	— .00668	44.268	44.014
N_2O	1.00327	— .00654	11.0	— .00747	44.285	43.996
Air	1.00026	— .00046	11.4	–	–	–
NH_3	1.00632	–	–	–	–	–

Rayleigh, Zeitschr. Phys. Chem. 52, 1905.

TABLE 60. — Compressibility of Air and Oxygen between 18° and 22° C.

Pressures in metres uf mercury, pv, relative.

Air	p	24.07	34.90	45.24	55.30	64.00	72.16	84.22	101.47	214.54	304.04
	pv	26968	26908	26791	26789	26778	26792	26840	27041	29585	32488
O_2	p	24.07	34.89	–	55.50	64.07	72.15	84.19	101.06	214.52	303.03
	pv	26843	26614	–	26185	26050	25858	25745	25639	26536	28756

Amagat, C. R. 1879.

RELATION BETWEEN PRESSURE, TEMPERATURE AND VOLUME OF SULPHUR DIOXIDE AND AMMONIA.*

TABLE 61.—Sulphur Dioxide.

Original volume 100000 under one atmosphere of pressure and the temperature of the experiments as indicated at the top of the different columns.

Pressure in Atmos.	Corresponding Volume for Experiments at Temperature —		
	58°.0	99°.6	183°.2
10	8560	9440	-
12	6360	7800	-
14	4040	6420	-
16	-	5310	-
18	-	4405	-
20	-	4030	-
24	-	3345	-
28	-	2780	3180
32	-	2305	2640
36	-	1935	2260
40	-	1450	2040
50	-	-	1640
60	-	-	1375
70	-	-	1130
80	-	-	930
90	-	-	790
100	-	-	680
120	-	-	545
140	-	-	430
160	-	-	325

Volume.	Pressure in Atmospheres for Experiments at Temperature —		
	58°.0	99°.6	183°.2
10000	-	9.60	-
9000	9.60	10.35	-
8000	10.40	11.85	-
7000	11.55	13.05	-
6000	12.30	14.70	-
5000	13.15	16.70	-
4000	14.00	20.15	-
3500	14.40	23.00	-
3000	-	26.40	29.10
2500	-	30.15	33.25
2000	-	35.20	40.95
1500	-	39.60	55.20
1000	-	-	76.00
500	-	-	117.20

TABLE 62.—Ammonia.

Original volume 100000 under one atmosphere of pressure and the temperature of the experiments as indicated at the top of the different columns.

Pressure in Atmos.	Corresponding Volume for Experiments at Temperature —		
	46°.6	99°.6	183°.6
10	9500	-	-
12.5	7245	7635	-
15	5880	6305	-
20	-	4645	4875
25	-	3560	3835
30	-	2875	3185
35	-	2440	2680
40	-	2080	2345
45	-	1795	2035
50	-	1490	1775
55	-	1250	1590
60	-	975	1450
70	-	-	1245
80	-	-	1125
90	-	-	1035
100	-	-	950

Volume.	Pressure in Atmospheres for Experiments at Temperature —			
	30°.2	46°.6	99°.6	183°.0
10000	8.85	9.50		-
9000	9.60	10.45		-
8000	10.40	11.50	12.00	-
7000	11.05	13.00	13.60	-
6000	11.80	14.75	15.55	-
5000	12.00	16.60	18.60	19.50
4000	-	18.35	22.70	24.00
3500	-	18.30	25.40	27.20
3000	-	-	29.20	31.50
2500	-	-	34.25	37.35
2000	-	-	41.45	45.50
1500	-	-	49.70	58.00
1000	-	-	59.65	93.60

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* From the experiments of Roth, "Wied. Ann." vol. 11, 1880.

TABLE 63.

COMPRESSIBILITY OF LIQUIDS.

If V_1 is the volume under pressure p_1 atmospheres at $t°C$, and V_2 is volume at pressure p_2 and the same temperature, then the compressibility coefficient may be defined at that temperature as

$$\beta_t = \frac{1}{V_1} \cdot \frac{V_1 - V_2}{p_1 - p_2}.$$

In absolute units (referred to megadynes) the coefficient is $\frac{1}{1.0137}$.

Substance.	t.	Pressures.	$\beta \cdot 10^6$	Reference.	Substance.	t.	Pressures.	$\beta \cdot 10^6$	Reference.
	°					°			
Acetone	0.00	1–500	82	1	Methyl alcohol	100.	8.68–37.3	221	3
"	0.00	500–1000	59	"	" "	18.10	8	120	2
"	0.00	1000–1500	47	"	Nitric acid	20.3	1–32	338	11
"	99.5	8.94–36.5	276	3	Oils: Almond	17.	–	55	8
Benzole	5.95	8	83	2	Olive	20.5	–	63	"
"	17.9	8	92	"	Paraffin	14.8	–	63	6
"	15.4	1–4	87	4	Petroleum	16.5	–	70	12
"	78.8	1–4	126	"	Rock	19.4	–	75	8
Carbon bisulphide	0.00	1–500	66	1	Rape-seed	20.3	–	60	"
" "	0.00	500–1000	53	"	Turpentin	19.7	–	79	"
" "	0.00	1000–1500	43	"	Toluene	10.	–	79	13
" "	49.2	1000–1500	51	"	"	100.	–	150	"
Chloroform	0.	–	101	5	Xylene	10.	–	74	"
"	20.	–	128	"	"	100.	–	132	"
"	40.	–	162	"	Paraffins: C_8H_{14}	23.	0–1	159	14
"	60.	–	204	"	C_7H_{16}	"	"	134	"
"	100.	8–9	211	3	C_8H_{18}	"	"	121	"
"	100.	19–34	206	"	C_9H_{20}	"	"	113	"
Collodium	14.8		97	6	$C_{10}H_{22}$	"	"	105	"
Ethyl alcohol	28.	150–200	86	7	$C_{12}H_{26}$	"	"	92	"
" "	28.	150–400	81	"	$C_{14}H_{80}$	"	"	83	"
" "	65.	150–200	110	"	$C_{16}H_{84}$	"	"	75	"
" "	65.	150–400	100	"	Water	0.	1–25	525	1
" "	100.	150–200	168	"	"	10.	"	500	"
" "	100.	150–400	132	"	"	20.	"	491	"
" "	185.	150–200	320	"	"	0.	25–50	516	"
" "	185.	150–400	245	"	"	10.	"	492	"
" "	310.	150–200	4200	"	"	20.	"	476	"
" "	310.	150–400	1530	"	"	0.	1–100	511	"
" "	0.	1–50	96	1	"	10.	"	483	"
" "	20.	1–50	112	"	"	20.	"	468	"
" "	40.	1–50	125	"	"	50.	"	449	"
" "	0.	100–200	85	"	"	100.	"	478	"
" "	0.	300–400	73	"	"	0.	100–200	492	"
" "	20.	300–400	78	"	"	10.	"	461	"
" "	40.	300–400	87	"	"	20.	"	442	"
" "	0.	500–600	64	"	"	50.	"	425	"
" "	0.	700–800	56	"	"	100.	"	468	"
" "	20.	700–800	62	"	"	0.	1–500	475	"
" "	40.	700–800	65	"	"	20.4	"	434	"
" "	0.	900–1000	52	"	"	48.85	"	416	"
Ethyl chloride	11.	8.5–34.2	138	3	"	0.	500–1000	416	"
" "	15.2	8.7–37.2	153	"	"	0.	1000–1500	358	"
" "	61.5	12.6–34.4	256	"	"	20.4	"	338	"
" "	99.0	12.8–34.5	495	"	"	48.85	"	325	"
Glycerine	20.5	–	25	8	"	0.	1500–2000	324	"
"	14.8	–	22	6	"	0.	2000–2500	292	"
Mercury	0.	–	3.92	9	"	0.	2500–3000	261	"
"	0.	–	3.90	10	"	48.85	"	254	"
Methyl alcohol	14.7	8.50–37.1	104	3					

For references see page 83.

TABLE 64.

COMPRESSIBILITY AND BULK MODULI OF SOLIDS.

Solid.	Compression per unit volume per atmo. $\times 10^6$.	Authority.	Calculated values of bulk modulus in —	
			Grammes per sq. cm.	Pounds per sq. in.
Crystals: Barite	1.93	Voigt	535×10^6	7.61×10^6
Beryl	0.747	“	1384 “	19.68 “
Fluorspar	1.20	“	860 “	12.24 “
Pyrites	1.14	“	906 “	12.89 “
Quartz	2.67	“	387 “	5.50 “
Rock salt	4.20*	“	246 “	3.50 “
Sylvine	7.45*	“	138 “	1.97 “
Topaz	0.61	“	1694 “	24.11 “
Tourmaline	0.113	“	9140 “	130.10 “
Brass	0.95	Amagat	1090 “	15.48 “
Copper	0.86	Buchanan	1202 “	17.10 “
Delta metal	1.02	Amagat	1012 “	14.41 “
Lead	2.76	“	374 “	5.32 “
Steel	0.68	“	1518 “	21.61 “
Glass	2.2–2.9	“	405 “	5.76 “

NOTE: Winklemann, Schott, and Straulel (Wied Ann. 61, 63, 1897; 68, 1899) give the following coefficients (among others) for various Jena glasses in terms of the volume decrease divided by the increase of pressure expressed in kilogrammes per square millimetre:

No.	Glass.	Compressibility.	No.	Glass.	Compressibility.
665		7520	2154	Kalibleisilicat	3660
1299	Barytborosilicat	5800	S 208	Heaviest Bleisilicat	3550
16	Natronkalkzinksilicat	4530	500	Very heavy “	3510
278		3790	S 196	Tonerdborat with sodium, baryte	3470

* Röntgen and Schneider by piezometric experiments obtained 5.0×10^{-6} for rock salt, and 5.6×10^{-6} for sylvine (Wied. Ann., vol. 31).

References to Tables 63 and 64.

Liquids (Table 63):

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4 Pagliani-Palazzo, Mem. Acad. Lin. (3) 19, 1883.
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TABLE 65.

SPECIFIC GRAVITIES CORRESPONDING TO THE BEAUMÉ SCALE.

The specific gravities are for 15.56°C (60°F) referred to water at the same temperature as unity. For specific gravities less than unity the values are calculated from the formula:

$$\text{Degrees Beaumé} = 145 - \frac{145}{\text{Specific Gravity}}.$$

For specific gravities greater than unity from:

$$\text{Degrees Beaumé} = \frac{140}{\text{Specific Gravity}} - 130.$$

Specific Gravities less than 1.

Specific Gravity.	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
	Degrees Beaumé.									
0.60	103.33	99.51	95.81	92.22	88.75	85.38	82.12	78.95	75.88	72.90
.70	70.00	67.18	64.44	61.78	59.19	56.67	54.21	51.82	49.49	47.22
.80	45.00	42.84	40.73	38.68	36.67	34.71	32.79	30.92	29.09	27.30
.90	25.56	23.85	22.17	20.54	18.94	17.37	15.83	14.33	12.86	11.41
1.00	10.00									

Specific Gravities greater than 1.

Specific Gravity.	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
	Degrees Beaumé.									
1.00	0.00	1.44	2.84	4.22	5.58	6.91	8.21	9.49	10.74	11.97
1.10	13.18	14.37	15.54	16.68	17.81	18.91	20.00	21.07	22.12	23.15
1.20	24.17	25.16	26.15	27.11	28.06	29.00	29.92	30.83	31.72	32.60
1.30	33.46	34.31	35.15	35.98	36.79	37.59	38.38	39.16	39.93	40.68
1.40	41.43	42.16	42.89	43.60	44.31	45.00	45.68	46.36	47.03	47.68
1.50	48.33	48.97	49.60	50.23	50.84	51.45	52.05	52.64	53.23	53.80
1.60	54.38	54.94	55.49	56.04	56.58	57.12	57.65	58.17	58.69	59.20
1.70	59.71	60.20	60.70	61.18	61.67	62.14	62.61	63.08	63.54	63.99
1.80	64.44	64.89	65.33	65.76	66.20	66.62				

TABLE 66.

DENSITY OR MASS IN GRAMMES PER CUBIC CENTIMETRE AND POUNDS PER CUBIC FOOT OF THE ELEMENTS, LIQUID OR SOLID.

Element.	Physical State.	Grammes per cu. cm.	Pounds per cu. foot.	Temperature.*	Authority.
Aluminum	cast	2.56–2.58	160–161		
"	wrought	2.65–2.80	165–175		
"	pure	2.58	161	4	Mallet, 1882.
Antimony	vacuo-distilled	6.618	413.2	20	Kahlbaum, 1902.
"	ditto-compressed	6.691	417.7	20	"
"	amorphous	6.22	388		Hérard.
Argon	liquid	1.3845	86.43	—183	Baly-Donnan.
"	"	1.4233	88.86	—189	" "
Arsenic	crystallized	5.73	358	14	
"	amorph. br.-black	3.70	231		Geuther
"	yellow	3.88	242		Linck
Barium		3.75	234		
Beryllium		1.73–2.13	108–133		
Bismuth	solid	9.70–9.90	605–618		
"	electrolytic	9.747	608.5		Classen, 1890.
"	vacuo-distilled	9.781	610.6	20	Kahlbaum, 1902.
"	liquid	10.00	624	271	Vincentini-Omodei.
"	solid	9.67	604	271	" "
Boron	crystal	2.5–2.6	156–162		
"	amorph. pure	2.45	153		Moissan
Bromine	liquid	3.15	197		
Cadmium	cast	8.54–8.57	5.33–5.35		
"	wrought	8.67	541		
"	vacuo-distilled	8.648	539.9	20	Kahlbaum, 1902.
"	solid	8.37	522	318	Vincentini-Omodei.
"	liquid	7.99	498	318	" "
Cæsium		1.88	117		
Calcium		1.52	95		Arndt, Ch. Ber. 1904.
Carbon	diamond	3.47–3.56	216–222		Liversidge.
"	graphite	2.10–2.32	131–145		
Cerium	electrolytic	6.79	424		Muthmann-Weiss
"	pure	7.02	438		" "
Chlorine	liquid	1.507	94.1	—33.6	Drugman-Ramsay
Chromium		6.52–6.73	407–420		
"	pure	6.92	432	20	Moissan.
Cobalt		8.71	544	21	Tilden, Ch. C. 1898.
Columbium	liquid	7.1–7.4	440–460		
Copper	cast	8.80–8.95	549–558		
"	drawn	8.93–8.95	557–558		
"	wrought	8.85–8.95	552–558		
"	electrolytic	8.88–8.95	554–558		
"	vacuo-distilled	8.9326	557.7	20	Kahlbaum, 1902.
"	ditto-compressed	8.9376	558.0	20	" "
"	liquid	8.217	513		Roberts-Wrightson.
Erbium		4.77	298		St. Meyer, Z. Ph. Ch. 37.
Fluorine	liquid	1.14	71	—200	Moissan-Dewar.
Gallium		5.93	370	23	de Boisbaudran.
Germanium		5.46	341	20	Wimkler.
Glucinium		1.86–2.06	116–127		
Gold	cast	19.3	1200		
"	wrought	19.33	1207		
"	vacuo-distilled	18.88	1178	20	Kahlbaum, 1902.
"	ditto-compressed	19.27	1202	20	"
Hydrogen	liquid	0.070	4.3	—252	Dewar, Ch. News, 1904.
Indium		7.12–7.42	444–463		

* Where the temperature is not given, ordinary atmospheric temperature is understood.

Compiled from Clarke's Constants of Nature, Landolt-Börnstein-Meyerhoffer's Tables, and other sources. Where no authority is stated, the values are mostly means from various sources.

DENSITY OR MASS IN GRAMMES PER CUBIC CENTIMETRE AND POUNDS PER CUBIC FOOT OF THE ELEMENTS, LIQUID OR SOLID.

Element.	Physical State.	Grammes per cu. cm.	Pounds per cu. foot.	Temperature.*	Authority.
Iridium		22.42	1399	17	Deville-Debray
Iodine		4.7–4.9	293–306	17	
Iron	pure	7.85–7.88	490–492		
“	gray cast	7.03–7.13	439–445		
“	white cast	7.58–7.73	473–482		
“	wrought	7.80–7.90	487–492		
“	liquid	6.88	429		Roberts-Austen
“	steel	7.60–7.80	474–487		
Lanthanum		6.15	384		Muthmann-Weiss
Lead	cast	11.37	710	24	Reich
“	wrought	11.36	709	24	“
“	solid	11.005	686	325	Vincentini-Omodei
“	liquid	10.645	664	325	“ “
“	vacuo-distilled	11.342	708.1	20	Kahlbaum, 1902
“	ditto-compressed	11.347	708.4	20	“ “
Lithium		0.534	33.3	20	Richards-Brink, ’07
Magnesium		1.69–1.75	105–109		
Manganese		7.4	460		
Mercury	liquid	13.596	848.8	0	Regnault, Volkmann
“	“	13.546	845.7	20	
“	“	13.690	854.7	—38.8	Vincentini-Omodei
“	solid	14.193	886.1	—38.8	Mallet
“	“	14.383	897.9	—188	Dewar, 1902
Molybdenum		8.4–8.6	520–540		
Nickel		8.60–8.90	540–550		
Niobium		7.2	450		
Nitrogen	liquid	0.810	50.5	—195	Baly-Donnan, 1902
“	“	0.854	53.3	—205	“ “ “
Osmium		22.5	1400		
Oxygen	liquid	1.14	71	184	
Palladium		11.4	711		
Phosphorus	white	1.83	114		
“	red	2.20	137		
“	metallic	2.34	146	15	Hittorf
Platinum		21.2–21.7	1320–1350		
Potassium		0.86–0.88	54–55		
“	solid	0.851	53.7	62.1	Vincentini-Omodei
“	liquid	0.830	53.8	62.1	“ “
Præsodymium		6.475	404		Muthmann-Weiss
Rhodium		11.0–12.1	686–755		
Rubidium		1.532	95.6	20	Richards-Brink, ’07
Ruthenium		12.3	768		
Samarium		7.7–7.8	480–490		Muthmann-Weiss
Selenium		4.3–4.8	270–300		
Silicon		2.0–2.4	120–150		
Silver	cast	10.42–10.53	650–657		
“	wrought	10.6	661		
“	vacuo-distilled	10.492	655.0	20	Kahlbaum, 1902
“	ditto-compressed	10.503	655.7	20	“ “
“	liquid	9.51	593		Roberts-Austen
Sodium		0.9712	60.63	20	Richards-Brink, ’07
“	solid	0.9519	59.4	97.6	Vincentini-Omodei
“	liquid	0.9287	58.0	97.6	“ “
“		1.0066	62.84	—188	Dewar
Strontium		2.50–2.58	156–161		Matthiessen
Sulphur		2.0–2.1	120–130		
“	liquid	1.811	113.1	113	Vincentini-Omodei

* Where the temperature is not given, ordinary atmospheric temperature is understood.

TABLE 66 (*continued*). — **Density or Mass in grammes per cubic centimetre and pounds per cubic foot of the elements, liquid or solid.**

Element.	Physical State.	Grammes per cu. cm.	Pounds per cu. foot.	Temperature.*	Authority.
Tantalum		10.4–12.8	650–800		
Tellurium	crystallized	6.25	390		
"	amorphous	6.02	376	20	Beljankin.
Thallium		11.8–11.9	736–742		
Thorium		11.0	690	17	Nilson.
Tin	white, cast	7.29	455		Matthiessen.
"	" wrought	7.30	455		
"	" crystallized	6.97–7.18	435–448		
"	" solid	7.184	454	226	Vincentini-Omodei.
"	" liquid	6.99	436		
"	gray	5.8	360		
Titanium		3.5	220		
Tungsten		18.6–19.1	1160–1190		
Uranium		18.7	1170	13	Zimmermann.
Vanadium		5.5	340		Roscoe.
Xenon	liquid	3.52	220		Ramsay-Travers.
Yttrium		3.8	240		St. Meyer.
Zinc	cast	7.04–7.16	439–447		
"	wrought	7.19	449		
"	vacuo-distilled	6.92	432	20	Kahlbaum, 1902.
"	ditto-compressed	7.13	445	20	" "
"	liquid	6.48	404		Roberts-Wrightson.
Zirconium		4.14	258		Froost.

TABLE 67 — **Mass in grammes per cubic centimetre and in pounds per cubic foot of different kinds of wood.**

The wood is supposed to be seasoned and of average dryness.

Wood.	Grammes per cubic centimetre.	Pounds per cubic foot.	Wood.	Grammes per cubic centimetre.	Pounds per cubic foot.
Alder	0.42–0.68	26–42	Hazel	0.60–0.80	37–49
Apple	0.66–0.84	41–52	Hickory	0.60–0.93	37–58
Ash	0.65–0.85	40–53	Holly	0.76	47
Bamboo	0.31–0.40	19–25	Iron-bark	1.03	64
Basswood. See Linden.			Juniper	0.56	35
Beech	0.70–0.90	43–56	Laburnum	0.92	57
Blue gum	1.00	52	Lancewood	0.68–1.00	42–62
Birch	0.51–0.77	32–48	Lignum vitæ	1.17–1.33	73–83
Box	0.95–1.16	59–72	Linden or Lime-tree	0.32–0.59	20–37
Bullet-tree	1.05	65	Locust	0.67–0.71	42–44
Butternut	0.38	24	Logwood	.91	57
Cedar	0.49–0.57	30–35	Mahogany, Honduras	0.66	35
Cherry	0.70–0.90	43–56	" Spanish	0.85	53
Cork	0.22–0.26	14–16	Maple	0.62–0.75	39–47
Dogwood	0.76	47	Oak	0.60–0.90	37–56
Ebony	1.11–1.33	69–83	Pear-tree	0.61–0.73	38–45
Elm	0.54–0.60	34–37	Plum-tree	0.66–0.78	41–49
Fir or Pine, American White	0.35–0.50	22–31	Poplar	0.35–0.5	22–31
" Larch	0.50–0.56	31–35	Satinwood	0.95	59
" Pitch	0.83–0.85	52–53	Sycamore	0.40–0.60	24–37
" Red	0.48–0.70	30–44	Teak, Indian	0.66–0.88	41–55
" Scotch	0.43–0.53	27–33	" African	0.98	61
" Spruce	0.48–0.70	30–44	Walnut	0.64–0.70	40–43
" Yellow	0.37–0.60	23–37	Water gum	1.00	62
Greenheart	0.93–1.04	58–65	Willow	0.40–0.60	24–37

* Where the temperature is not given, ordinary atmospheric temperature is understood.

Table 66.

DENSITY OR MASS IN GRAMMES PER CUBIC CENTIMETRE AND POUNDS PER CUBIC FOOT OF VARIOUS SOLIDS.*

Substance.	Grammes per cubic centimetre.	Pounds per cubic foot.
Agate	2.5–2.7	156–168
Alabaster:		
Carbonate	2.69–2.78	168–173
Sulphate	2.26–2.32	141–145
Alum, potash	1.75	109
Amber	1.06–1.11	66–69
Anthracite	1.4–1.8	87–112
Apatite	3.16–3.22	197–201
Aragonite	3.0	187
Arsenic	5.7–5.72	356–358
Asbestos	2.0–2.8	125–175
Asphaltum	1.1–1.5	69–94
Barite	4.5	281
Basalt	2.4–3.1	150–193
Beeswax	0.96–0.97	60–61
Bole	2.2–2.5	137–156
Bone	1.7–2.0	106–125
Boracite	2.9–3.0	181–187
Borax	1.7–1.8	106–112
Borax glass	2.6	162
Boron	2.45–2.69	153–168
Brick	1.4–2.2	87–137
Butter	0.86–0.87	53–54
Calamine	4.1–4.5	255–280
Calcspar	2.6–2.8	162–175
Carbon. See Graphite, etc.		
Caoutchouc	0.92–0.99	57–62
Celestine	3.9	243
Cement:		
Pulverized loose	1.15–1.7	72–105
Pressed	1.85	115
Set	2.7–3.0	168–187
Cetin	0.88–0.94	55–59
Chalk	1.9–2.8	118–175
Charcoal:		
Oak	0.57	35
Pine	0.28–0.44	17.5–27.5
Chrome yellow	6.00	374
Cinnabar	8.12	507
Clay	1.8–2.6	122–162
Clayslate	2.8–2.9	175–180
Coal, soft	1.2–1.5	75–94
Cobaltite	6.4–7.3	400–455
Cocoa butter	0.89–0.91	56–57
Coke	1.0–1.7	62–105
Copal	1.04–1.14	65–71
Corundum	3.9–4.0	245–250
Diamond	3.5–3.6	220–225
Anthracitic	1.66	104
Carbonado	3.01–3.25	188–203
Diorite	2.8–3.1	175–193
Dolomite	2.4–2.9	150–181
Earth, dry	1.6–1.9	100–120
Ebonite	1.15	72
Emery	4.0	250
Epsom salts:		
Crystalline	1.7–1.8	106–112
Anhydrous	2.6	162
Feldspar	2.53–2.58	158–161
Flint	2.63	164
Fluor spar	3.14–3.18	196–198
Gabronite	2.9–3.0	181–187
Gamboge	1.2	75
Galena	7.3–7.6	460–470
Garnet	3.6–3.8	230–335
Gas carbon	1.88	119
Glass:		
Common	2.4–2.8	150–175
Flint	2.9–5.9	180–370
Glauber's salt	1.4–1.5	87–93
Glue	1.27	80
Gneiss	2.4–3.2	150–200
Granite	2.0–3.0	125–187
Graphite	1.9–2.3	120–140
Gravel	1.2–1.8	94–112
Gray copper ore	4.4–5.4	275–335
Green stone	2.9–3.0	180–185
Gum arabic	1.3–1.4	80–85
Gunpowder:		
Loose	0.9	56
Tamped	1.75	109
Gypsum, burnt	1.81	113
Hornblende	3.0	187
Ice	0.88–0.91	55–57
Iodine	4.67	291
Ivory	1.83–1.92	114–120
Kaolin	2.2	137
Lava:		
Basaltic	2.8–3.0	175–185
Trachytic	2.0–2.7	125–168
Lead acetate	2.4	150
Leather:		
Dry	0.86	54
Greased	1.02	64
Lime:		
Mortar	1.65–1.78	103–111
Slaked	1.3–1.4	81–87
Lime	2.3–3.2	144–200
Limestone	2.0–3.1	125–190
Litharge:		
Artificial	9.3–9.4	580–585
Natural	7.8–8.0	489–492
Magnesia	3.2	200
Magnesite	3.0	187
Magnetite	4.9–5.2	306–324
Malachite	3.7–4.1	231–256
Manganese:		
Red ore	3.46	216
Black ore	3.9–4.1	243–256
Marble	2.5–2.8	157–177
Marl	1.6–2.5	100–156
Masonry	1.85–2.3	116–144
Meerschaum	.99–1.28	61.8–79.9
Melaphyre	2.6	162
Mica	2.6–3.2	165–200
Mortar	1.75	109
Mud	1.6	102
Nitroglycerine	1.6	99
Ochre	3.5	218
Opal	2.2	137
Orpiment	3.4–3.5	212–218
Paper	0.7–1.15	44–72
Paraffin	0.87–0.91	54–57
Peat	0.84	52
Phosphorus, white	1.82	114
Pitch	1.07	67
Porcelain	2.3–2.5	143–156
Porphyry	2.6–2.9	162–181
Potash	2.26	141

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* For elements, see Table 66.

TABLE 68 (*continued*).—Density of Various Solids.

Substance.	Grammes per cubic centimetre.	Pounds per cubic foot.	Substance.	Grammes per cubic centimetre.	Pounds per cubic foot.
Pyrites	4.9–5.2	306–324	Snow, loose . .	0.125	7.8
Pyrolusite . . .	3.7–4.6	231–287	Soapstone, Steatite .	2.6–2.8	162–175
Pumice stone . .	0.37–0.9	23–56	Soda:		
Quartz	2.65	165	Roasted . . .	2.5	156
Resin	1.07	67	Crystalline . .	1.45	90
Rock crystal . .	2.6	162	Spathic iron ore .	3.7–3.9	231–243
Rock salt . . .	2.28–2.41	142–150	Starch	1.53	95
Sal ammoniac . .	1.5–1.6	94–100	Stibnite	4.6–4.7	287–293
Saltpetre . . .	1.95–2.08	122–130	Strontianite . . .	3.7	231
Sand:			Syenite	2.1–3.0	130–190
Dry	1.40–1.65	87–103	Sugar	1.61	100
Damp . . .	1.90–2.05	119–128	Talc	2.7	168
Sandstone . . .	2.0–3.2	124–200	Tallow	0.91–0.97	570–605
Selenium . . .	4.2–4.8	262–300	Tellurium . . .	6.38–6.42	398–401
Serpentine . . .	2.43–2.66	152–166	Tile	1.4–2.3	87–143
Shale	2.6	162	Tinstone . . .	6.4–7.0	399–437
Silicon	2.0–2.5	125–156	Topaz	3.5–3.6	219–223
Siliceous earth . .	2.66	166	Tourmaline . . .	2.94–3.24	183–202
Slag, furnace . .	2.0–3.9	124–240	Trachyte . . .	2.7–2.8	168–175
Slate	2.6–3.3	162–205	Trap	2.6–2.7	162–170

TABLE 69.—Density or Mass in Grammes per Cubic Centimetre and Pounds per Cubic Foot of Various Alloys (Brasses and Bronzes).

Alloy.	Grammes per cubic centimetre.	Pounds per cubic foot.
Brasses: Yellow, 70Cu + 30Zn, cast	8.44	527
" " " rolled	8.56	534
" " " drawn	8.70	542
" Red, 90Cu + 10Zn	8.60	536
" White, 50Cu + 50Zn	8.20	511
Bronzes: 90Cu + 10Sn	8.78	548
" 85Cu + 15Sn	8.89	555
" 80Cu + 20Sn	8.74	545
" 75Cu + 25Sn	8.83	551
German Silver: Chinese, 26.3Cu + 36.6Zn + 36.8 Ni	8.30	518
" " Berlin (1) 52Cu + 26Zn + 22Ni	8.45	527
" " " (2) 59Cu + 30Zn + 11Ni	8.34	520
" " " (3) 63Cu + 30Zn + 6Ni	8.30	518
" " Nickelin	8.77	547
Lead and Tin: 87.5Pb + 12.5Sn	10.60	661
" " " 84Pb + 16Sn	10.33	644
" " " 77.8Pb + 22.2Sn	10.05	627
" " " 63.7Pb + 36.3Sn	9.43	588
" " " 46.7Pb + 53.3Sn	8.73	545
" " " 30.5Pb + 69.5Sn	8.24	514
Bismuth, Lead, and Tin: 53Bi + 40Pb + 7Cd	10.56	659
Wood's Metal: 50Bi + 25Pb + 12.5Cd + 12.5Sn . . .	9.70	605
Cadmium and Tin: 32Cd + 68Sn	7.70	480
Gold and Copper: 98Au + 2Cu	18.84	1176
" " " 96Au + 4Cu	18.36	1145
" " " 94Au + 6Cu	17.95	1120
" " " 92Au + 8Cu	17.52	1093
" " " 90Au + 10Cu	17.16	1071
" " " 88Au + 12Cu	16.81	1049
" " " 86Au + 14Cu	16.47	1027
Aluminum and Copper: 10Al + 90Cu	7.69	480
" " " 5Al + 95Cu	8.37	522
" " " 3Al + 97Cu	8.69	542
Aluminum and Zinc: 91Al + 9Zn	2.80	175
Platinum and Iridium: 90Pt + 10Ir	21.62	1348
" " " 85Pt + 15Ir	21.62	1348
" " " 66.67Pt + 33.33Ir	21.87	1364
" " " 5Pt + 95Ir	22.38	1396

TABLE 70.

DENSITY OF LIQUIDS.

Density or mass in grammes per cubic centimetre and in pounds per cubic foot of various liquids.

Liquid.	Grammes per cubic centimetre.	Pounds per cubic foot	Temp. C.
Acetone	0.792	49.4	0°
Alcohol, ethyl	0.791	49.4	0
" methyl	0.810	50.5	0
" proof spirit	0.916	57.2	0
Anilin	1.035	64.5	0
Benzene	0.899	56.1	0
Bromine	3.187	199.0	0
Carbolic acid (crude)	0.950–0.965	59.2–60.2	15
Carbon disulphide	1.293	80.6	15
Chloroform	1.480	92.3	18
Ether	0.736	45.9	0
Gasoline	0.66–0.69	41.0–43.0	–
Glycerine	1.260	78.6	0
Milk	1.028–1.035	64.2–64.6	–
Naphtha (wood)	0.848–0.810	52.9–50.5	0
Naphtha (petroleum ether)	0.665	41.5	15
Oils: Amber	0.800	49.9	15
Anise-seed	0.996	61.1	16
Camphor	0.910	56.8	–
Castor	0.969	60.5	15
Cocoanut	0.925	57.7	15
Cotton seed	0.926	60.2	16
Creosote	1.040–1.100	64.9–68.6	15
Lard	0.920	57.4	15
Lavender	0.877	54.7	16
Lemon	0.844	52.7	16
Linseed (boiled)	0.942	58.8	15
Mineral (lubricating)	0.900–0.925	56.2–57.7	20
Olive	0.918	57.3	15
Palm	0.905	56.5	15
Pine	0.850–0.860	53.0–54.0	15
Poppy	0.924	57.7	–
Rapeseed (crude)	0.915	57.1	15
" (refined)	0.913	57.0	15
Resin	0.955	59.6	15
Train *or* Whale	0.918–0.925	57.3–57.7	15
Turpentine	0.873	54.2	16
Valerian	0.965	60.2	16
Petroleum	0.878	54.8	0
" (light)	0.795–0.805	49.6–50.2	15
Pyroligneous acid	0.800	49.9	0
Sea water	1.025	64.0	15
Soda lye	1.210	75.5	17
Water	1.000	62.4	4

TABLE 71.

DENSITY OF GASES.

The following table gives the density of the gases at 0° C, 76 cm. pressure, at sea-level and latitude 45° relative to air as unity and under the same conditions; also the weight of one litre in grammes and one cubic foot in pounds.

Gas.	Specific Gravity.	Grammes per litre.	Pounds per cubic foot.	Reference.
Air	1.000	1.2928	.08071	Rayleigh; Leduc.
Acetylene	0.92	1.1620	.07254	Berthelot, 1860.
Ammonia	0.597	0.7621	.04758	Leduc, C. R. 125, 1897.
Argon	1.379	1.782	.1112	Ramsey-Travers, Proc. R. Soc. 67, 1900.
Bromine	5.524	7.1426	.4459	Jahn, 1882.
Butane	2.01	2.594	.16194	Frankland, Ann. Ch. Pharm. 71.
Carbon dioxide	1.5291	1.9652	.12269	Rayleigh, Proc. R. Soc. 62, 1897.
" monoxide	0.9672	1.2506	.07807	" " " " "
Chlorine	2.491	3.1666	.19769	Leduc, C. R. 125, 1897.
Coal gas { from	0.320	0.414	.02583	
Coal gas { to	0.740	0.957	.05973	
Cyanogen	1.806	2.3261	.14522	Gay-Lussac.
Ethane	1.075	1.3421	.08379	Kolbe, Ann. Chem. Pharm. 65.
Fluorine	1.26	1.697	.1059	Moissan, C. R. 109.
Helium	1.368	0.1787	.01116	Ramsey-Travers, Proc. R. Soc. 67, 1900.
Hydrofluoric acid	0.7126	0.894	.05581	Thorpe-Hambley, J. Chem. Soc. 53.
Hydrobromic acid	2.71	3.6163	.2258	Löwig, Gmelin-Kraut, Org. Chem.
Hydrochloric acid	1.2692	1.6283	.10165	Leduc, C. R. 125, 1897.
Hydrogen	0.0696	0.09004	.005621	Rayleigh, Proc. R. Soc. 53, 1893.
Hydrogen sulphide	1.1895	1.5230	.09508	Leduc, C. R. 125, 1897.
Krypton	2.818	3.654	.2281	Ramsey-Travers, Proc. R. Soc. 67, 1900.
Methane	0.5576	0.7160	.04470	Thomson.
Neon	0.674	0.893	.0558	Ramsey-Travers, Proc. R. Soc. 67, 1900.
Nitrogen	0.9673	1.2542	.07829	Rayleigh, Proc. R. Soc. 62, 1897.
Nitric oxide, NO	1.0387	1.3417	.08376	Leduc, C. R. 116, 1893.
Nitrous oxide, N_2O	1.5301	1.9688	.12291	" C. R. 125, 1897.
Oxygen	1.053	1.4292	.08922	Rayleigh, Proc. R. Soc. 62, 1897.
Sulphur dioxide	2.2639	2.8611	.17862	Leduc, C. R. 117, 1893.
Steam at 100°	0.469	0.581	.0363	
Xenon	4.422	5.717	.3569	Ramsey-Travers, Proc. R. Soc. 67, 1900.

Compiled partly from Landolt-Börnstein-Meyerhoffer's Physikalisch-Chemische Tabellen.

TABLE 72.

DENSITY OF AQUEOUS SOLUTIONS.*

The following table gives the density of solutions of various salts in water. The numbers give the weight in grammes per cubic centimetre. For brevity the substance is indicated by formula only.

Substance.	Weight of the dissolved substance in 100 parts by weight of the solution.									Temp. C.	Authority.
	5	10	15	20	25	30	40	50	60		
K_2O	1.047	1.098	1.153	1.214	1.284	1.354	1.503	1.659	1.809	15.	Schiff.
KOH	1.040	1.082	1.027	1.076	1.229	1.286	1.410	1.538	1.666	15.	"
Na_2O	1.073	1.144	1.218	1.284	1.354	1.421	1.557	1.689	1.829	15.	"
NaOH	1.058	1.114	1.169	1.224	1.279	1.331	1.436	1.539	1.642	15.	"
NH_3	0.978	0.959	0.940	0.924	0.909	0.896	–	–	–	16.	Carius.
NH_4Cl	1.015	1.030	1.044	1.058	1.072	–	–	–	–	15.	Gerlach.
KCl	1.031	1.065	1.099	1.135	–	–	–	–	–	15.	"
NaCl	1.035	1.072	1.110	1.150	1.191	–	–	–	–	15.	"
LiCl	1.029	1.057	1.085	1.116	1.147	1.181	1.255	–	–	15.	"
$CaCl_2$	1.041	1.086	1.132	1.181	1.232	1.286	1.402	–	–	15.	"
$CaCl_2 + 6H_2O$	1.019	1.040	1.061	1.083	1.105	1.128	1.176	1.225	1.276	18.	Schiff.
$AlCl_3$	1.035	1.072	1.111	1.153	1.196	1.241	1.340	–	–	15.	Gerlach.
$MgCl_2$	1.041	1.085	1.130	1.177	1.226	1.278	–	–	–	15.	"
$MgCl_2 + 6H_2O$	1.014	1.032	1.049	1.067	1.085	1.103	1.141	1.183	1.222	24.	Schiff.
$ZnCl_2$	1.043	1.089	1.135	1.184	1.236	1.289	1.417	1.563	1.737	19.5	Kremers.
$CdCl_2$	1.043	1.087	1.138	1.193	1.254	1.319	1.469	1.653	1.887	19.5	"
$SrCl_2$	1.044	1.092	1.143	1.198	1.257	1.321	–	–	–	15.	Gerlach.
$SrCl_2 + 6H_2O$	1.027	1.053	1.082	1.111	1.042	1.174	1.242	1.317	–	15.	"
$BaCl_2$	1.045	1.094	1.147	1.205	1.269	–	–	–	–	15.	"
$BaCl_2 + 2H_2O$	1.035	1.075	1.119	1.166	1.217	1.273	–	–	–	21.	Schiff.
$CuCl_2$	1.044	1.091	1.155	1.221	1.291	1.360	1.527	–	–	17.5	Franz.
NCl_2	1.048	1.098	1.157	1.223	1.299	–	–	–	–	17.5	"
$HgCl_2$	1.041	1.092	–	–	–	–	–	–	–	20.	Mendelejeff.
Fe_2Cl_6	1.041	1.086	1.130	1.179	1.232	1.290	1.413	1.545	1.668	17.5	Hager.
$PtCl_4$	1.046	1.097	1.153	1.214	1.285	1.362	1.546	1.785	–	–	Precht.
$SnCl_2 + 2H_2O$	1.032	1.067	1.104	1.143	1.185	1.229	1.329	1.444	1.580	15.	Gerlach.
$SnCl_4 + 5H_2O$	1.029	1.058	1.089	1.122	1.157	1.193	1.274	1.365	1.467	15.	"
LiBr	1.033	1.070	1.111	1.154	1.202	1.252	1.366	1.498	–	19.5	Kremers.
KBr	1.035	1.073	1.114	1.157	1.205	1.254	1.364	–	–	19.5	"
NaBr	1.038	1.078	1.123	1.172	1.224	1.279	1.408	1.563	–	19.5	"
$MgBr_2$	1.041	1.085	1.135	1.189	1.245	1.308	1.449	1.623	–	19.5	"
$ZnBr_2$	1.043	1.091	1.194	1.202	1.263	1.328	1.473	1.648	1.873	19.5	"
$CdBr_2$	1.041	1.088	1.139	1.197	1.258	1.324	1.479	1.678	–	19.5	"
$CaBr_2$	1.042	1.087	1.137	1.192	2.250	1.313	1.459	1.639	–	19.5	"
$BaBr_2$	1.043	1.090	1.142	1.199	1.260	1.327	1.483	1.683	–	19.5	"
$SrBr_2$	1.043	1.089	1.140	1.198	1.260	1.328	1.489	1.693	1.953	19.5	"
KI	1.036	1.076	1.118	1.164	1.216	1.269	1.394	1.544	1.732	19.5	"
LiI	1.036	1.077	1.122	1.170	1.222	1.278	1.412	1.573	1.775	19.5	"
NaI	1.038	1.080	1.126	1.177	1.232	1.292	1.430	1.598	1.808	19.5	"
ZnI_2	1.043	1.089	1.138	1.194	1.253	1.366	1.418	1.648	1.873	19.5	"
CdI_2	1.042	1.086	1.136	1.192	1.251	1.317	1.474	1.678	–	19.5	"
MgI_2	1.041	1.086	1.137	1.192	1.252	1.318	1.472	1.666	1.913	19.5	"
CaI_2	1.042	1.088	1.138	1.196	1.258	1.319	1.475	1.663	1.908	19.5	"
SrI_2	1.043	1.089	1.140	1.198	1.260	1.328	1.489	1.693	1.953	19.5	"
BaI_2	1.043	1.089	1.141	1.199	1.263	1.331	1.493	1.702	1.968	19.5	"
$NaClO_3$	1.035	1.068	1.106	1.145	1.188	1.233	1.329	–	–	19.5	"
$NaBrO_3$	1.039	1.081	1.127	1.176	1.229	1.287	–	–	–	19.5	"
KNO_3	1.031	1.064	1.099	1.135	–	–	–	–	–	15.	Gerlach.
$NaNO_3$	1.031	1.065	1.101	1.140	1.180	1.222	1.313	1.416	–	20.2	Schiff.
$AgNO_3$	1.044	1.090	1.140	1.195	1.255	1.322	1.479	1.675	1.918	15.	Kohlrausch.

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* Compiled from two papers on the subject by Gerlach in the "Zeit. für Anal. Chim.," vols. 8 and 27.

TABLE 72 (*continued*).

DENSITY OF AQUEOUS SOLUTIONS.

Substance.	Weight of the dissolved substance in 100 parts by weight of the solution.									Temp. C.	Authority.
	5	10	15	20	25	30	40	50	60		
NH_4NO_3	1.020	1.041	1.063	1.085	1.107	1.131	1.178	1.229	1.282	17.5	Gerlach.
$ZnNO_3$	1.048	1.095	1.146	1.201	1.263	1.325	1.456	1.597	–	17.5	Franz.
$ZnNO_3+6H_2O$	–	1.054	–	1.113	–	1.178	1.250	1.329	–	14.	Oudemans.
$Ca(NO_3)_2$	1.037	1.075	1.118	1.162	1.211	1.260	1.367	1.482	1.604	17.5	Gerlach.
$Cu(NO_3)_2$	1.044	1.093	1.143	1.203	1.263	1.328	1.471	–	–	17.5	Franz.
$Sr(NO_3)_2$	1.039	1.083	1.129	1.179	–	–	–	–	–	19.5	Kremers.
$Pb(NO_3)_2$	1.043	1.091	1.143	1.199	1.262	1.332	–	–	–	17.5	Gerlach.
$Cd(NO_3)_2$	1.052	1.097	1.150	1.212	1.283	1.355	1.536	1.759	–	17.5	Franz.
$Co(NO_3)_2$	1.045	1.090	1.137	1.192	1.252	1.318	1.465	–	–	17.5	"
$Ni(NO_3)_2$	1.045	1.090	1.137	1.192	1.252	1.318	1.465	–	–	17.5	"
$Fe_2(NO_3)_6$	1.039	1.076	1.117	1.160	1.210	1.261	1.373	1.496	1.657	17.5	"
$Mg(NO_3)_2+6H_2O$	1.018	1.038	1.060	1.082	1.105	1.129	1.179	1.232	–	21	Schiff.
$Mn(NO_3)_2+6H_2O$	1.025	1.052	1.079	1.108	1.138	1.169	1.235	1.307	1.386	8	Oudemans.
K_2CO_3	1.044	1.092	1.141	1.192	1.245	1.300	1.417	1.543	–	15	Gerlach.
$K_2CO_3 + 2H_2O$	1.037	1.072	1.110	1.150	1.191	1.233	1.320	1.415	1.511	15.	"
$Na_2CO_310H_2O$	1.019	1.038	1.057	1.077	1.098	1.118	–	–	–	15.	"
$(NH_4)_2SO_4$	1.027	1.055	1.084	1.113	1.142	1.170	1.226	1.287	–	19.	Schiff.
$Fe_2(SO_4)_3$	1.045	1.096	1.150	1.207	1.270	1.336	1.489	–	–	18.	Hager.
$FeSO_4 + 7H_2O$	1.025	1.053	1.081	1.111	1.141	1.173	1.238	–	–	17.2	Schiff.
$MgSO_4$	1.051	1.104	1.161	1.221	1.284	–	–	–	–	15	Gerlach.
$MgSO + 7H_2O$	1.025	1.050	1.075	1.101	1.129	1.155	1.215	1.278	–	15.	"
$Na_2So_4 + 10H_2O$	1.019	1.039	1.059	1.081	1.102	1.124	–	–	–	15.	"
$CuSO_4 + 5H_2O$	1.031	1.064	1.098	1.134	1.173	1.213	–	–	–	18.	Schiff.
$MnSO_4 + 4H_2O$	1.031	1.064	1.099	1.135	1.174	1.214	1.303	1.398	–	15.	Gerlach.
$ZnSO_4 + 7H_2O$	1.027	1.057	1.089	1.122	1.156	1.191	1.269	1.351	1.443	20.5	Schiff.
$Fe_2(SO)_3+K_2SO_4 +24H_2O$	1.026	1.045	1.066	1.088	1.112	1.141	–	–	–	17.5	Franz.
$Cr_2(SO)_3+K_2SO_4 + 24H_2O$	1.016	1.033	1.051	1.073	1.099	1.126	1.188	1.287	1.454	17.5	"
$MgSO_4 + K_2SO_4 + 6H_2O$	1.032	1.066	1.101	1.138	–	–	–	–	–	15.	Schiff.
$(NH_4)_2SO_4 + FeSO_4 + 6H_2O$	1.028	1.058	1.090	1.122	1.154	1.191	–	–	–	19.	"
K_2CrO_4	1.039	1.082	1.127	1.174	1.225	1.279	1.397	–	–	19.5	"
$K_2Cr_2O_7$	1.035	1.071	1.108	–	–	–	–	–	–	19.5	Kremers.
$Fe(Cy)_6K_4$	1.028	1.059	1.092	1.126	–	–	–	–	–	15.	Schiff.
$Fe(Cy)_6K_3$	1.025	1.053	1.145	1.179	–	–	–	–	–	13	"
$Pb(C_2H_3O_2)_2 + 3H_2O$	1.031	1.064	1.100	1.137	1.177	1.220	1.315	1.426	–	15.	Gerlach.
$2NaOH + As_2O_5 + 24H_2O$	1.020	1.042	1.066	1.089	1.114	1.140	1.194	–	–	14.	Schiff.
	5	10	15	20	30	40	60	80	100		
SO_3	1.040	1.084	1.132	1.179	1.277	1.389	1.564	1.840	–	15.	Brineau.
SO_2	1.013	1.028	1.045	1.063	–	–	–	–	–	4.	Schiff.
N_2O_5	1.033	1.069	1.104	1.141	1.217	1.294	1.422	1.506	–	15.	Kolb.
$C_4H_6O_6$	1.021	1.047	1.070	1.096	1.150	1.207	–	–	–	15.	Gerlach.
$C_6H_8O_7$	1.018	1.038	1.058	1.079	1.123	1.170	1.273	–	–	15.	"
Cane sugar	1.019	1.039	1.060	1.082	1.129	1.178	1.289	–	–	17.5	"
HCl	1.025	1.050	1.075	1.101	1.151	1.200	–	–	–	15.	Kolb.
HBr	1.035	1.073	1.114	1.158	1.257	1.376	–	–	–	14.	Topsöe.
HI	1.037	1.077	1.118	1.165	1.271	1.400	–	–	–	13.	"
H_2SO_4	1.032	1.069	1.106	1.145	1.223	1.307	1.501	1.732	1.838	15.	Kolb.
H_2SiFl_6	1.040	1.082	1.127	1.174	1.273	–	–	–	–	17.5	Stolba.
P_2O_5	1.035	1.077	1.119	1.167	1.271	1.385	1.676	–	–	17.5	Hager.
$P_2O_5 + 3H_2O$	1.027	1.057	1.086	1.119	1.188	1.264	1.438	–	–	15.	Schiff.
HNO	1.028	1.056	1.088	1.119	1.184	1.250	1.373	1.459	1.528	15.	Kolb.
$C_2H_4O_2$	1.007	1.014	1.021	1.028	1.041	1.052	1.068	1.075	1.055	15.	Oudemans.

TABLE 73.

DENSITY OF WATER AT DIFFERENT TEMPERATURES BETWEEN 0° AND 36° C.

The temperatures are for the hydrogen thermometer.

Temp. C.	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
0	0.999 868	874	881	887	893	899	905	911	916	922
1	927	932	936	941	945	950	954	957	961	965
2	968	971	974	977	980	982	985	987	989	991
3	992	994	995	996	997	998	999	999	000	000
4	1.000 000	000	000	999*	999*	998*	997*	996*	995*	993*
5	0.999 992	990	988	986	984	982	979	977	974	971
6	968	965	962	958	954	951	947	943	938	934
7	929	925	920	915	910	904	899	893	888	882
8	876	870	864	857	851	844	837	830	823	816
9	808	801	793	785	778	769	761	753	744	736
10	727	718	709	700	691	681	672	662	652	642
11	632	622	612	601	591	580	569	558	547	536
12	525	513	502	490	478	466	454	442	429	417
13	404	391	379	366	353	339	326	312	299	285
14	271	257	243	229	215	200	186	171	156	141
15	126	111	096	081	065	050	034	018	002	986*
16	0.998 970	953	937	920	904	887	870	853	836	819
17	801	784	766	749	731	713	695	677	659	640
18	622	603	585	566	547	528	509	490	471	451
19	432	412	392	372	352	332	312	292	271	251
20	230	210	189	168	147	126	105	083	062	040
21	019	997*	975*	953*	931*	909*	887*	864*	842*	819*
22	0.997 797	774	751	728	705	682	659	635	612	588
23	565	541	517	493	469	445	421	396	372	347
24	323	298	273	248	223	198	173	147	122	096
25	071	045	019	994*	968*	941*	915*	889*	863*	836*
26	0.996 810	783	756	730	703	676	648	621	594	567
27	539	512	484	456	428	400	372	344	316	288
28	259	231	202	174	145	116	087	058	029	000
29	0.995 971	941	912	882	853	823	793	763	733	703
30	673	643	613	582	552	521	491	460	429	398
31	367	336	305	273	242	211	179	148	116	084
32	052	020	988*	956*	924*	892*	859*	827*	794*	762*
33	0.994 729	696	663	630	597	564	531	498	464	431
34	398	364	330	296	263	229	195	161	126	092
35	058	023	989	954	920	885	850	815	780	745

If we put D'_t for the density of water containing air and D_t for the density of water free from air, we get the following, due to Marek:

t=	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
$10^7(D_t - D'_t)$=	25	27	29	31	32	33	33	34	34	33	32
t=	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20—32**	
$10^7(D_t - D'_t)$=	31	29	27	25	22	19	16	12	8	4 negligible	

From the observations of Thiesen, Scheel, and Diesselhorst, Wiss. Abh. Phys.-Techn. Reichs. 3, 68; 1900.

TABLE 74.

VOLUME IN CUBIC CENTIMETRES AT VARIOUS TEMPERATURES OF A CUBIC CENTIMETRE OF WATER AT THE TEMPERATURE OF MAXIMUM DENSITY.

The water in this case is supposed to be free from air. The temperatures are by the hydrogen thermometer.

Temp. C.	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
0	1.000 132	126	119	113	107	101	095	089	084	079
1	073	069	064	059	055	051	047	043	039	035
2	032	029	026	023	020	018	016	013	011	009
3	008	006	005	004	003	002	001	001	000	000
4	000	000	000	001	001	002	003	004	005	007
5	008	010	012	014	016	018	021	023	026	029
6	032	035	039	042	046	050	054	058	062	066
7	071	075	080	085	090	096	101	107	112	118
8	124	130	137	143	149	156	163	170	177	184
9	192	199	207	215	223	231	239	247	256	264
10	273	282	291	300	309	319	328	338	348	358
11	368	378	388	399	409	420	431	442	453	464
12	476	487	499	511	522	534	547	559	571	584
13	596	609	622	635	648	661	675	688	702	715
14	729	743	757	772	786	800	815	830	844	859
15	874	890	905	920	936	951	967	983	999	015*
16	1.001 031	048	064	081	098	114	131	148	165	183
17	200	218	235	253	271	289	307	325	343	361
18	380	399	417	436	455	474	493	513	532	551
19	571	591	610	630	650	671	691	711	732	752
20	773	794	815	836	857	878	899	921	942	964
21	985	007*	029*	051*	073*	096*	118*	140*	163*	186*
22	1.002 208	231	254	277	300	324	347	370	394	418
23	441	465	489	513	538	562	586	611	635	660
24	685	710	735	760	785	810	835	861	886	912
25	938	964	990	016*	042*	068*	094*	121*	147*	174*
26	1.003 201	227	254	281	308	336	363	390	418	445
27	473	501	529	556	585	613	641	669	698	726
28	755	783	812	841	870	899	928	957	987	016*
29	1.004 046	075	105	135	165	194	225	255	285	315
30	346	376	407	437	468	499	530	561	592	623
31	655	686	717	749	781	812	844	876	908	940
32	972	005*	037*	070*	102*	135*	167*	200*	233*	266*
33	1.005 299	332	365	399	432	465	499	533	566	600
34	634	668	702	736	771	805	839	874	908	943
35	978	013*	047*	082*	118*	153*	188*	223*	259*	294*

From the observations of Thiesen, Scheel, and Diesselhorst, Wiss. Abh. Phys.-Techn. Reichs. 3, 68; 1900.

TABLE 75.

DENSITY AND VOLUME OF WATER.

The mass of one cubic centimetre at 4° C. is taken as unity.

Temp. C.	Density.	Volume.	Temp. C.	Density.	Volume.
—10°	0.99815	1.00186	+35°	0.99406	1.00598
—9	843	157	36	371	633
—8	869	131	37	336	669
—7	892	108	38	299	706
—6	912	088	39	262	743
—5	0.99930	1.00070	40	0.99224	1.00782
—4	945	055	41	186	821
—3	958	042	42	147	861
—2	970	031	43	107	901
—1	979	021	44	066	943
+0	0.99987	1.00013	45	0.99025	1.00985
1	993	007	46	0.98982	1.01028
2	997	003	47	940	072
3	999	001	48	896	116
4	1.00000	1.00000	49	852	162
5	0.99999	1.00001	50	0.98807	1.01207
6	997	003	51	762	254
7	993	007	52	715	301
8	988	012	53	669	349
9	981	019	54	621	398
10	0.99973	1.00027	55	0.98573	1.01448
11	963	037	60	324	705
12	952	048	65	059	979
13	940	060	70	0.97781	1.02270
14	927	073	75	489	576
15	0.99913	1.00087	80	0.97183	1.02899
16	897	103	85	0.96865	1.03237
17	880	120	90	534	590
18	862	138	95	192	959
19	843	157	100	0.95838	1.04343
20	0.99823	1.00177	110	0.9510	1.0515
21	802	198	120	.9434	1.0601
22	780	221	130	.9352	1.0693
23	756	244	140	.9264	1.0794
24	732	268	150	.9173	1.0902
25	0.99707	1.00294	160	0.9075	1.1019
26	681	320	170	.8973	1.1145
27	654	347	180	.8866	1.1279
28	626	375	190	.8750	1.1429
29	597	405	200	.8628	1.1590
30	0.99567	1.00435	210	0.850	1.177
31	537	466	220	.837	1.195
32	505	497	230	.823	1.215
33	473	530	240	.809	1.236
34	440	563	250	.794	1.259

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[*] From —10° to 0° the values are due to means from Pierre, Weidner, and Rosetti; from 0° to 35°, to Thiesen, Scheel, and Diesselhorst; 31° to 100°, to Thiesen; 110° to 250°, to means from the works of Ramsey, Young, Waterston, and Hirn.

Table 76.

DENSITY OF MERCURY.

Density or mass in grammes per cubic centimetre, and the volume in cubic centimetres of one gramme of mercury. The density at 0° is taken as 13.59545,* and the volume at temperature t is $V_t = V_0(1 + .000181792t + 175 \times 10^{-12}t^2 + 35116 \times 10^{-15}t^8)$.†

Temp. C.	Mass in grammes per cu. cm.	Volume of 1 gramme in cu. cms.	Temp. C.	Mass in grammes per cu. cm.	Volume of 1 gramme in cu. cms.
—10°	13.6202	0.0734205	**30°**	13.5217	0.0739552
—9	6177	4338	31	5193	9686
—8	6152	4472	32	5168	9820
—7	6128	4606	33	5144	9953
—6	6103	4739	34	5119	40087
—5	13.6078	0.0734873	**35**	13.5095	0.0740221
—4	6053	5006	36	5070	0354
—3	6029	5140	37	5046	0488
—2	6004	5273	38	5021	0622
—1	5979	5407	39	4997	0756
0	13.5955	0.0735540	**40**	13.4973	0.0740891
1	5930	5674	50	4729	2229
2	5906	5808	60	4486	3569
3	5881	5941	70	4244	4910
4	5856	6075	80	4003	6252
5	13.5832	0.0736209	**90**	13.3762	0.0747594
6	5807	6342	100	3522	8939
7	5782	6476	110	3283	50285
8	5758	6610	120	3044	1633
9	5733	6744	130	2805	2982
10	13.5708	0.0736877	**140**	13.2567	0.0754334
11	5684	7011	150	2330	5688
12	5659	7145	160	2093	7044
13	5634	7278	170	1856	8402
14	5610	7412	180	1620	9764
15	13.5585	0.0737546	**190**	13.1384	0.0761128
16	5561	7680	200	1148	2495
17	5536	7813	210	0913	3865
18	5512	7947	220	0678	5239
19	5487	8081	230	0443	6616
20	13.5462	0.0738215	**240**	13.0209	0.0767996
21	5438	8348	250	12.9975	9381
22	5413	8482	260	9741	70769
23	5389	8616	270	9507	2161
24	5364	8750	280	9273	3558
25	13.5340	0.0738883	**290**	12.9039	0.0774958
26	5315	9017	300	8806	6364
27	5291	9151	310	8572	7774
28	5266	9285	320	8339	9189
29	5242	9419	330	8105	80609
30	13.5217	0.0739552	**340**	12.7872	0.0782033
			350	7638	3464
			360	7405	4900

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* Thiesen und Scheel, Thätigkeitsbericht der Phys. Reichsanstalt, 1897–1898.

† Broch, *l. c.*

TABLE 77.

SPECIFIC GRAVITY OF AQUEOUS ETHYL ALCOHOL.

(a) The numbers here tabulated are the specific gravities at 60° F., in terms of water at the same temperature, of water containing the percentages by weight of alcohol of specific gravity .7938, with reference to the same temperatures.*

Percentage of alcohol by weight.	0	1	2	3	4	5	6	7	8	9
	Specific gravity at 15°.56 C. in terms of water at the same temperature.									
0	1.0000	.9981	.9965	.9947	.9930	.9914	.9898	.9884	.9869	.9855
10	.9841	.9828	.9815	.9802	.9789	.9778	.9766	.9753	.9741	.9728
20	.9716	.9703	.9691	.9678	.9665	.9652	.9638	.9623	.9609	.9593
30	.9578	.9560	.9544	.9528	.9511	.9490	.9470	.9452	.9434	.9416
40	.9396	.9376	.9356	.9335	.9314	.9292	.9270	.9249	.9228	.9206
50	0.9184	.9160	.9135	.9113	.9090	.9069	.9047	.9025	.9001	.8979
60	.8956	.8932	.8908	.8886	.8863	.8840	.8816	.8793	.8769	.8745
70	.8721	.8696	.8672	.8649	.8625	.8603	.8581	.8557	.8533	.8508
80	.8483	.8459	.8434	.8408	.8382	.8357	.8331	.8305	.8279	.8254
90	.8228	.8199	.8172	.8145	.8118	.8089	.8061	.8031	.8001	.7969

(b) The following are the values adopted by the "Kaiserlichen Normal-Aichungs Kommission." They are based on Mendelejeff's formula,† and are for alcohol of specific gravity .79425, at 15° C., in terms of water at 15° C.; temperatures measured by the hydrogen thermometer.

Percentage of alcohol by weight.	0	1	2	3	4	5	6	7	8	9
	Specific gravity at 15° C. in terms of water at the same temperature.									
0	1.00000	.99812	.99630	.99454	.99284	.99120	.98963	.98812	.98667	.98528
10	.98393	.98262	.98135	.98010	.97888	.97768	.97648	.97528	.97408	.97287
20	.97164	.97040	.96913	.96783	.96650	.96513	.96373	.96228	.96080	.95927
30	.95770	.95608	.95443	.95273	.95099	.94920	.94738	.94552	.94363	.94169
40	.93973	.93773	.93570	.93365	.93157	.92947	.92734	.92519	.92303	.92085
50	0.91865	.91644	.91421	.91197	.90972	.90746	.90519	.90292	.90063	.89834
60	89604	.89373	.89141	.88909	.88676	.88443	.88208	.87974	.87738	.87502
70	87265	.87028	.86789	.86550	.86310	.86070	.85828	.85586	.85342	.85098
80	84852	.84606	.84358	.84108	.83857	.83604	.83349	.83091	.82832	.82569
90	82304	.82036	.81763	.81488	.81207	.80923	.80634	.80339	.80040	.79735

(c) The following values have the same authority as the last; the percentage of alcohol being given by volume instead of by weight, and the temperature 15°.56 C. on the mercury in Thuringian glass thermometer; the specific gravity of the absolute alcohol being .79391.

Percentage of alcohol by volume.	0	1	2	3	4	5	6	7	8	9
	Specific gravity at 15°.56 C. in terms of water at same temperature.									
0	1.00000	.99847	.99699	.99555	.99415	.99279	.99147	.90019	.98895	.98774
10	.98657	.98543	.98432	.98324	.98218	.98114	.98011	.97909	.97808	.97708
20	.97608	.97507	.97406	.97304	.97201	.97097	.96991	.96883	.96772	.96658
30	.96541	.96421	.96298	.96172	.96043	.95910	.95773	.95632	.95487	.95338
40	.95185	.95029	.94868	.94704	.94536	.94364	.94188	.94008	.93824	.93636
50	0.93445	.93250	.93052	.92850	.92646	.92439	.92229	.92015	.91799	.91580
60	.91358	.91134	.90907	.90678	.90447	.90214	.89978	.89740	.89499	.89256
70	.89010	.88762	.88511	.88257	.88000	.87740	.87477	.87211	.86943	.86670
80	.86395	.86116	.85833	.85547	.85256	.84961	.84660	.84355	.84044	.83726
90	.83400	.83065	.82721	.82365	.81997	.81616	.81217	.80800	.80359	.79891

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* Fownes, "Phil. Trans. Roy. Soc." 1847.

† "Pogg. Ann." vol. 138, 1869.

Table 78.

DENSITY OF AQUEOUS METHYL ALCOHOL.*

Densities of aqueous methyl alcohol at 0° and 15.56 C., water at 4° C. being taken as 100000. The numbers in the columns *a* and *b* are the coefficients in the equation $\rho_t = \rho_0 - at - bt^2$ where ρ_t is the density at temperature t. This equation may be taken to hold between 0° and 20° C.

Percentage of CH_4O.	Density at 0° C.	Density at 15°.56 C.	*a*	*b*
0	99987	99907	−6.0	0.705
1	99806	99729	−5.4	.694
2	99631	99554	−4.8	.681
3	99462	99382	−3.9	.670
4	99299	99214	−3.0	.659
5	99142	99048	−2.2	0.648
6	98990	98893	−1.2	.634
7	98843	98726	−0.2	.621
8	98701	98569	+0.9	.609
9	98563	98414	2.1	.596
10	98429	98262	3.3	0.581
11	98299	98111	4.8	.569
12	98171	97962	6.2	.552
13	98048	97814	7.8	.536
14	97926	97668	9.5	.519
15	97806	97523	11.0	0.500
16	97689	97379	12.5	.480
17	97573	97235	14.5	.461
18	97459	97093	16.2	.440
19	97346	96950	18.3	.420
20	97233	96808	20.0	0.398
21	97120	96666	22.2	.373
22	97007	96524	24.3	.350
23	96894	96381	26.4	.321
24	96780	96238	29.0	.291
25	96665	96093	31.3	0.261
26	96549	95949	33.8	.230
27	96430	95802	36.0	.191
28	96310	95655	38.8	.151
29	96187	95506	41.1	.106
Equation $\rho_t = \rho_0 - at$				
30	96057	95367	44.36	Term bt^2 negligible.
31	95921	95211	45.66	
32	95783	95053	46.93	
33	95643	94894	48.17	
34	95500	94732	49.39	
35	95354	94567	50.58	
36	95204	94399	51.75	
37	95051	94228	52.89	
38	94895	94055	54.01	
39	94734	93877	55.10	
40	94571	93697	56.16	
41	94400	93510	57.20	
42	94239	93335	58.22	
43	94076	93155	59.20	
44	93911	92975	60.17	
45	93744	92793	61.10	
46	93575	92610	62.01	
47	93403	92424	62.90	
48	93229	92237	63.76	
49	93052	92047	64.60	

Percentage of CH_4O.	Density at 0° C.	Density at 15°.56 C.	*a*
50	92873	91855	65.41
51	92691	91661	66.19
52	92507	91465	66.95
53	92320	91267	67.68
54	92130	91066	68.39
55	91938	90863	69.07
56	91742	90657	69.72
57	91544	90450	70.35
58	91343	90239	70.96
59	91139	90026	71.54
60	90917	89798	71.96
61	90706	89580	72.37
62	90492	89358	72.91
63	90276	89133	73.45
64	90056	88905	73.98
65	89835	88676	74.51
66	89611	88443	75.05
67	89384	88208	75.57
68	89154	87970	76.10
69	88922	87714	76.62
70	88687	87487	77.14
71	88470	87262	77.66
72	88237	87021	78.18
73	88003	86779	78.69
74	87767	86535	79.20
75	87530	86290	79.71
76	87290	86042	80.22
77	87049	85793	80.72
78	86806	85542	81.23
79	86561	85290	81.73
80	86314	85035	82.22
81	86066	84779	82.72
82	85816	84521	83.21
83	85564	84262	83.70
84	85310	84001	84.19
85	85055	83738	84.67
86	84798	83473	85.16
87	84539	83207	85.64
88	84278	82938	86.12
89	84015	82668	86.59
90	83751	82396	87.07
91	83485	82123	87.54
92	83218	81849	88.01
93	82948	81572	88.48
94	82677	81293	88.94
95	82404	81013	89.40
96	82129	80731	89.86
97	81853	80448	90.32
98	81576	80164	90.78
99	81295	79872	91.23
100	81015	79589	91.68

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* Quoted from the results of Dittmar & Fawsitt, "Trans. Roy. Soc. Edin." vol. 33.

VARIATION OF THE DENSITY OF ALCOHOL WITH TEMPERATURE.

(a) The density of alcohol at $t°$ in terms of water at $4°$ is given* by the following equation:

$$d_t = 0.80025 - 0.0008340t - 00000029t^2.$$

From this formula the following table has been calculated.

Temp. C.	Density or Mass in grammes per cubic centimetre.									
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
0	.80625	.80541	.80457	.80374	.80290	.80207	.80123	.80039	.79956	.79872
10	.79788	.79704	.79620	.79535	.79451	.79367	.79283	.79198	.79114	.79029
20	.78945	.78860	.78775	.78691	.78606	.78522	.78437	.78352	.78267	.78182
30	.78097	.78012	.77927	.77841	.77756	.77671	.77585	.77500	.77414	.77329

(b) Variations with temperature of the density of water containing different percentages of alcohol. Water at $4°$ C. is taken as unity.†

Percentage of alcohol by weight.	Density at temp. C.				Percentage of alcohol by weight.	Density at temp. C.			
	0°	10°	20°	30°		0°	10°	20°	30°
0	0.99988	0.99975	0.99831	0.99579	**50**	0.92940	0.92182	0.91400	0.90577
5	.99135	.99113	.98945	.98680	55	.91848	.91074	.90275	.89456
10	.98493	.98409	.98195	.97892	60	.90742	.89944	.89129	.88304
15	.97995	.97816	.97527	.97142	65	.89595	.88790	.97961	.87125
20	.97566	.97263	.96877	.96413	70	.88420	.87613	.86781	.85925
25	0.97115	0.96672	0.96185	0.95628	**75**	0.87245	0.86427	0.85580	0.84719
30	.96540	.95998	.95403	.94751	80	.86035	.85215	.84366	.83483
35	.95784	.95174	.94514	.93813	85	.84789	.83967	.83115	.82232
40	.94939	.94255	.93511	.92787	90	.83482	.82665	.81801	.80918
45	.93977	.93254	.92493	.91710	95	.82119	.81291	.80433	.79553
50	0.92940	0.92182	0.91400	0.90577	**100**	0.80625	0.79788	0.78945	0.78096

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* Mendelejeff, "Pogg. Ann." vol. 138.

† Quoted from Landolt and Börnstein, "Phys. Chem. Tab." p. 359.

VELOCITY OF SOUND IN SOLIDS.

The numbers given in this table refer to the velocity of sound along a bar of the substance, and hence depend on the Young's Modulus of elasticity of the material. The elastic constants of most of the materials given in this table vary through a somewhat wide range, and hence the numbers can only be taken as rough approximations to the velocity which may be obtained in any particular case. When temperatures are not marked, between 10° and 20° is to be understood.

Substance.	Temp. C. °	Velocity in metres per second.	Velocity in feet per second.	Authority.
Metals: Aluminum	–	5104	16740	Masson.
Brass	–	3500	11480	Various.
Cadmium	–	2307	7570	Masson.
Cobalt	–	4724	15500	"
Copper	20	3560	11670	Wertheim.
"	100	3290	10800	"
"	200	2950	9690	"
Gold (soft)	20	1743	5717	"
" (hard)	–	2100	6890	Various.
Iron and soft steel	–	5000	16410	"
Iron	20	5130	16820	Wertheim.
"	100	5300	17390	"
"	200	4720	15480	"
" cast steel	20	4990	16360	"
" " "	200	4790	15710	"
Lead	20	1227	4026	"
Magnesium	–	4602	15100	Melde.
Nickel	–	4973	16320	Masson.
Palladium	–	3150	10340	Various.
Platinum	20	2690	8815	Wertheim.
"	100	2570	8437	"
"	200	2460	8079	"
Silver	20	2610	8553	"
"	100	2640	8658	"
Tin	–	2500	8200	Various.
Zinc	–	3700	12140	"
Various: Brick	–	3652	11980	Chladni.
Clay rock	–	3480	11420	Gray & Milne.
Cork	–	500	1640	Stefan.
Granite	–	3950	12960	Gray & Milne.
Marble	–	3810	12500	"
Paraffin	15	1304	4280	Warburg.
Slate	–	4510	14800	Gray & Milne.
Tallow	16	390	1280	Warburg.
Tuff	–	2850	9350	Gray & Milne.
Glass { from	–	5000	16410	Various.
Glass { to	–	6000	19690	"
Ivory	–	3013	9886	Ciccone & Campanile.
Vulcanized rubber (black)	0	54	177	Exner.
	50	31	102	"
" " (red)	0	69	226	"
" " "	70	34	111	"
Wax	17	880	2890	Stefan.
"	28	441	1450	"
Woods: Ash, along the fibre	–	4670	15310	Wertheim.
" across the rings	–	1390	4570	"
" along the rings	–	1260	4140	"
Beech, along the fibre	–	3340	10960	"
" across the rings	–	1840	6030	"
" along the rings	–	1415	4640	"
Elm, along the fibre	–	4120	13516	"
" across the rings	–	1420	4665	"
" along the rings	–	1013	3324	"
Fir, along the fibre	–	4640	15220	"
Maple "	–	4110	13470	"
Oak "	–	3850	12620	"
Pine "	–	3320	10900	"
Poplar "	–	4280	14050	"
Sycamore "	–	4460	14640	"

TABLE 81.

VELOCITY OF SOUND IN LIQUIDS AND GASES.

Substance.	Temp. C. °	Velocity in metres per second.	Velocity in feet per second.	Authority.
Liquids: Alcohol, 95%	12.5	1241.	4072.	Dorsing, 1908.
"	20.5	1213.	3980.	"
Ammonia, conc.	16.	1663.	5456.	"
Benzine	17.	1166.	3826.	"
Carbon bisulphide	15.	1161.	3809.	"
Chloroform	15.	983.	3225.	"
Ether	15.	1032.	3386.	"
NaCl, 10% sol.	15.	1470.	4823.	"
" 15% "	15.	1530.	5020.	"
" 20% "	15.	1650.	5414.	"
Turpentine oil	15.	1326.	4351.	"
Water, air-free	13.	1441.	4728.	"
" " "	19.	1461.	4794.	"
" " "	31.	1505.	4938.	"
" Lake Geneva	9.	1435.	4708.	Colladon-Sturm.
" Seine river	15.	1437.	4714.	Wertheim.
" " "	30.	1528.	5013.	"
" " "	60.	1724.	5657.	"
Gases: Air, dry, CO_2-free	0.	331.78	1088.5	Rowland.
" "	0.	331.36	1087.1	Violle, 1900.
" " CO_2-free	0.	331.92	1089.0	Thiesen, 1908.
" 1 atmosphere	0.	331.7	1088.	Mean.
" 25 "	0.	332.0	1089.	" (Witkowski).
" 50 "	0.	334.7	1098.	" "
" 100 "	0.	350.6	1150.	" "
"	20.	344.	1129.	
"	100.	386.	1266.	Stevens.
"	500.	553.	1814.	"
"	1000.	700.	2297.	"
Ammonia	0.	415.	1361.	Masson.
Carbon monoxide	0.	337.1	1106.	Wullner.
" "	0.	337.4	1107.	Dulong.
" dioxide	0.	258.0	846.	Brockendahl, 1906.
" disulphide	0.	189.	606.	Masson.
Chlorine	0.	206.4	677.	Martini.
"	0.	205.3	674.	Strecker.
Ethylene	0.	314.	1030.	Dulong.
Hydrogen	0.	1269.5	4165.	"
"	0.	1286.4	4221.	Zoch.
Illuminating gas	0.	490.4	1609.	"
Methane	0.	432.	1417.	Masson.
Nitric oxide	0.	325.	1066.	"
Nitrous oxide	0.	261.8	859.	Dulong.
Oxygen	0.	317.2	1041.	"
Vapors: Alcohol	0.	230.6	756.	Masson.
Ether	0.	179.2	588.	"
Water	0.	401.	1315.	"
"	100.	404.8	1328.	Treitz, 1903.
"	130.	424.4	1392.	"

MUSICAL SCALES.

The pitch relations between two notes may be expressed precisely (1) by the ratio of their vibration frequencies; (2) by the number of equally-tempered semitones between them (E. S.); also, less conveniently, (3) by the common logarithm of the ratio in (1); (4) by the lengths of the two portions of the tense string which will furnish the notes; and (5) in terms of the octave as unity. The ratio in (4) is the reciprocal of that in (1); the number for (5) is 1/12 of that for (2); the number for (2) is nearly 40 times that for (3).

Table 82 gives data for the middle octave, including vibration frequencies for three standards of pitch; $a = 435$ double vibrations per second, is the international standard and was adopted by the American Piano Manufacturers' Association. The "just-diatonic scale" of C-major is usually deduced, following Chladni, from the ratios of the three perfect major triads reduced to one octave, thus:

4 : 5 : 6
4 : 5 : 6 4 : 5 : 6
F A C E G B D
16 20 24 30 36 45 54
24 27 30 32 36 40 45 48

Other equivalent ratios and their values in E. S. are given in Table 83. By transferring D to the left and using the ratio 10 : 12 : 15 the scale of A-minor is obtained, which agrees with that of C-major except that D = 26 2/3. Nearly the same ratios are obtained from a series of harmonics beginning with the eighth; also by taking 12 successive perfect or Pythagorean fifths or fourths and reducing to one octave. Such calculations are most easily made by adding and subtracting intervals expressed in E. S. The notes needed to furnish a just major scale in other keys may be found by successive transpositions by fifths or fourths as shown in Table 83. Disregarding the usually negligible difference of 0.02 E. S., the table gives the 24 notes to the octave required in the simplest enharmonic organ; the notes fall into pairs that differ by a comma, 0.22 E. S. The line "mean tone" is based on Dom Bedos' rule for tuning the organ (1746). The tables have been checked by the data in Ellis' Helmholtz's "Sensations of Tone."

TABLE 82.

Note.	Interval.		Ratios.		Logarithms.		Number of Vibrations per second.				Beats for 0.1 E. S.
	Tempered.	Just.	Tempered.	Just.	Tempered.	Just.	Just.	Just.	Just.	Tempered.	
	E. S.	E. S.									
c′	0	0.	1.00	1.00000	0.0000	0.00000	*256*	*264*	258.7	258.7	1.50
	1			1.05926		.02509				274.0	
d′	2	2.04	1.125	1.12246	.05115	.05017	288	297	291.0	290.3	1.68
	3			1.18921		.07526				307.6	
e′	4	3.86	1.25	1.25992	.09691	.10034	320	330	323.4	325.9	1.89
f′	5	4.98	1.33	1.33484	.12494	.12543	341.3	352	344.9	345.3	2.00
	6			1.41421		.15051				365.8	
g′	7	7.02	1.50	1.49831	.17609	.17560	384	396	388	387.5	2.25
	8			1.58740		.20069				410.6	
a′	9	8.84	1.67	1.68179	.22185	.22577	426.7	*440*	431.1	*435.0*	2.52
	10			1.78180		.25086				460.9	
b′	11	10.88	1.875	1.88775	.27300	.27594	480	495	485.0	488.3	2.83
c″	12	12.00	2.00	2.00000	.30103	.30103	512	528	517.3	517.3	3.00

TABLE 83.

Key of		C		D		E	F		G		A		B	C
7 #s	C#		1.14 0.92		3.18 2.96		5.00 4.78	6.12 5.90		8.16 7.94		9.98 9.76		12.02 11.80
6 "	F#		1.14 0.92		2.96 2.74		5.00 4.78	6.12 5.90		8.16 7.94		9.98 9.76	11.10 10.88	
5 "	B		1.14 0.92		2.96 2.74	4.08 3.86		6.12 5.90		7.94 7.72		9.98 9.76	11.10 10.88	
4 "	E		0.92 0.70		2.96 2.74	4.08 3.86		6.12 5.90		7.94 7.72	9.06 8.84		11.10 10.88	
3 "	A		0.92 0.70	2.04 1.82		4.08 3.86		5.90 5.68		7.94 7.72	9.06 8.84		11.10 10.88	
2 "	D		0.92	2.04		4.08		5.90	7.02		9.06		10.88	
1 #	G	0.00		2.04		3.86		5.90	7.02		9.06		10.88	12.00
	C	0.00		2.04		3.86	4.98		7.02		8.84		10.88	12.00
1 ♭	F	0.00		1.82		3.86	4.98		7.02		8.84	9.96		12.00
2 ♭s	B♭	0.00		1.82	2.94		4.98		6.80		8.84	9.96		12.00
3 "	E♭	–.22		1.82	2.94		4.98		6.80	7.92		9.96		11.78
4 "	A♭	–.22	0.90		2.94		4.76		6.80	7.92		9.96		11.78
5 "	D♭	–.22	0.90		2.94		4.76	5.88		7.92		9.74		11.78
6 "	G♭		0.90		2.72		4.76	5.88		7.92		9.74	10.86	
7 "	C♭		0.90		2.72	3.84		5.88		7.70		9.74	10.86	
Harmonic Series		8 0.0	(17 1.05)	9 2.04	(19 2.98)	10 3.86	(21 4.70)	11 5.51	12 7.02	(25 7.73)	13 8.41	14 9.69	15 10.88	16 12.00
Cycle of fifths		0.0	1.14	2.04	3.18	4.08	5.22	6.12	7.02	8.16	9.06	10.20	11.10	12.24
Cycle of fourths		0.0	0.90	1.80	2.94	3.84	4.98	5.88	6.78	7.92	8.82	9.96	10.86	11.76
Mean tone		0.0	0.76	1.93	3.11	3.86	5.03	5.79	6.97	7.72	8.90	10.07	10.83	12.00
Equal 7 step		0.0		1.71	3.43		5.14		6.86		8.57	10.29		12.00

TABLE 84. ACCELERATION OF GRAVITY.

For Sea Level and Different Latitudes.

This table has been calculated from the formula $g_\phi = g_{45}\,[1 - .002662 \cos 2\phi]$,* where ϕ is the latitude.

Latitude ϕ.	g in cms. per sec. per sec.	Log.	g in inches per sec. per sec.	Log.	g in feet per sec. per sec.	Log.
0°	977.989	2.990334	385.034	2.585498	32.0862	1.506318
5	8.029	0352	.050	5517	.0875	6336
10	.147	0404	.096	5570	.0916	6388
15	.339	0490	.173	5655	.0977	6474
20	.600	0605	.275	5771	.1062	6590
25	978.922	2.990748	385.402	2.585914	32.1168	1.506732
30	9.295	0913	.548	6079	.1290	6898
31	.374	0949	.580	6114	.1316	6933
32	.456	0985	.612	6150	.1343	6969
33	.538	1021	.644	6187	.1370	7005
34	979.622	2.991059	385.677	2.586224	32.1398	1.507043
35	.707	1096	.711	6262	.1425	7080
36	.793	1135	.745	6300	.1454	7119
37	.880	1173	.779	6339	.1490	7167
38	.968	1212	.813	6377	.1511	7196
39	980.057	2.991251	385.849	2.586417	32.1540	1.507236
40	.147	1291	.884	6457	.1570	7275
41	.237	1331	.919	6496	.1607	7325
42	.327	1372	.955	6537	.1630	7356
43	.418	1411	.990	6577	.1659	7395
44	980.509	2.991452	386.026	2.586617	32.1688	1.507436
45	.600	1492	.062	6657	.1719	7476
46	.691	1532	.098	6698	.1748	7516
47	.782	1573	.134	6738	.1778	7557
48	.873	1613	.170	6778	.1808	7597
49	980.963	2.991653	386.205	2.586818	32.1838	1.507637
50	1.053	1693	.241	6858	.1867	7677
51	.143	1732	.276	6898	.1896	7716
52	.231	1772	.311	6937	.1924	7756
53	.318	1810	.345	6975	.1954	7794
54	981.407	2.991849	386.380	2.587014	32.1983	1.507833
55	.493	1887	.414	7053	.2011	7871
56	.578	1925	.447	7090	.2039	7909
57	.662	1962	.480	7127	.2067	7946
58	.744	1998	.513	7164	.2094	7983
59	981.825	2.992034	386.545	2.587200	32.2121	1.508018
60	.905	2070	.576	7235	.2147	8054
65	2.278	2234	.723	7400	.2276	8229
70	.600	2377	.849	7542	.2375	8361
75	.861	2492	.952	7657	.2460	8476
80	983.053	2.992577	387.028	2.587742	32.2523	1.508561
85	.171	2629	.074	7794	.2562	8613
90	.210	2646	.090	7812	.2575	8631

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* The constant .002662 is based on Harkness' data (Solar Parallax and Related Constants, Washington, 1891).

The acceleration of gravity for any latitude ϕ and elevation above sea level h is very nearly expressed by the equation

$$g_\phi = g_{45}\,(1 - .002662 \cos 2\phi)\left[1 - \frac{2h}{R}\left(1 - \frac{3\delta}{4\Delta}\right)\right],$$

where R is the earth's radius, δ the density of the surface strata, and Δ the mean density of the earth. When $\delta = 0$ we get the formula for elevation in air. For ordinary elevations on land $\frac{\delta}{\Delta}$ is nearly $\frac{1}{2}$, which gives for the correction at latitude 45° for elevated portions of the earth's surface

$$g_{45} \cdot \frac{5h}{4R} = 980.6 \times \frac{5h}{4R} = 1225.75\frac{h}{R} \text{ cm. per sec. per sec.}$$

$$= 386.062 \times \frac{5h}{4R} = 482.562\frac{h}{R} \text{ in. per sec. per sec.}$$

$$= 32.1719 \times \frac{5h}{4R} = 40.2149\frac{h}{R} \text{ feet per sec. per sec.}$$

This gives per 100 feet elevation a correction of

$$\left.\begin{array}{l} .00588 \text{ cm. per sec. per sec.} \\ .00232 \text{ in. per sec. per sec.} \\ .000193 \text{ feet per sec. per sec.} \end{array}\right\} \text{diminution.}$$

TABLE 85.

GRAVITY.

In this table the results of a number of the more recent gravity determinations are brought together. They serve to show the degree of accuracy which may be assumed for the numbers in Table 112. In general, gravity is a little lower than the calculated value for stations far inland and slightly higher on the coast line.

Place.	Latitude. N. +, S. —.	Elevation in metres.	Gravity, $\frac{\text{cm.}}{\text{sec}^2}$		Reference.
			Observed.	Reduced to sea level.	
Singapore	1° 17′	14	978.08	978.08	1
Georgetown, Ascension	—7 56	5	978.25	978.25	2
Green Mountain, Ascension	—7 57	686	978.10	978.23	2
Loanda, Angola	—8 49	46	978.15	978.16	2
Caroline Islands	—10 00	2	978.37	978.37	3
Bridgetown, Barbadoes	13 04	18	978.18	978.18	2
Jamestown, St. Helena	—15 55	10	978.67	978.67	2
Longwood, "	—15 57	533	978.53	978.59	2
Pakaoao, Sandwich Islands	20 43	3001	978.28	978.85	3
Lahaina, " "	20 52	3	978.86	978.86	3
Haiki, " "	20 56	117	978.91	978.93	3
Honolulu, " "	21 18	3	978.97	978.97	3
St. Georges, Bermuda	32 23	2	979.77	979.77	2
Sidney, Australia	—33 52	43	979.68	979.69	1
Cape Town	—33 56	11	979.62	979.62	2
Tokio, Japan	35 41	6	979.95	979.95	1
Auckland, New Zealand	—36 52	43	979.68	979.69	1
Mount Hamilton, Cal. (Lick Obs.)	37 20	1282	979.66	979.91	4
" " " "	37 20	1282	979.68	979.92	5
San Francisco, Cal.	37 47	114	979.96	979.98	4
" " "	37 47	114	980.02	980.04	5
Washington, D. C.*	38 53	10	980.11	980.11	4
Denver, Colo.	39 54	1645	979.68	979.98	5
York, Pa.	39 58	122	980.12	980.14	6
Ebensburgh, Pa.	40 27	651	980.08	980.20	6
Allegheny, Pa.	40 28	348	980.09	980.15	6
Hoboken, N. J.	40 44	11	980.27	980.27	4
Salt Lake City, Utah	40 46	1288	979.82	980.05	5
Chicago, Ill.	41 49	165	980.34	980.37	5
Pampaluna, Spain	42 49	450	980.34	980.42	7
Montreal, Canada	45 31	100	980.73	980.75	5
Geneva, Switzerland	46 12	405	980.58	980.64	8
" "	46 12	405	980.60	980.66	9
Berne, "	46 57	572	980.61	980.69	9
Zurich, "	47 23	466	980.67	980.74	9
Paris, France	48 50	67	980.96	980.97	8
Kew, England	51 28	7	981.20	981.20	8
Berlin, Germany	52 30	49	981.26	981.27	8
Port Simpson, B. C.	54 34	6	981.46	981.46	4
Burroughs Bay, Alaska	55 59	0	981.51	981.51	4
Wrangell, "	56 28	7	981.60	981.60	4
Sitka, "	57 03	8	981.69	981.69	4
St. Paul's Island, "	57 07	12	981.67	981.67	4
Juneau, "	58 18	5	981.74	981.74	4
Pyramid Harbor, "	59 10	5	981.82	981.82	4
Yakutat Bay, "	59 32	4	981.83	981.83	4

1 Smith: "United States Coast and Geodetic Survey Report for 1884," App. 14.
2 Preston: "United States Coast and Geodetic Survey Report for 1890," App. 12.
3 Preston: Ibid. 1888, App. 14.
4 Mendenhall: Ibid. 1891, App. 15.
5 Defforges: "Comptes Rendus," vol. 118, p. 231.
6 Pierce: "U. S. C. and G. S. Rep. 1883," App. 19.
7 Cebrian and Los Arcos: "Comptes Rendus des Séances de la Commission Permanente de l'Association Géodesique International," 1893.
8 Pierce: "U. S. C. and G. S. Report 1876, App. 15, and 1881, App. 17."
9 Messerschmidt: Same reference as 7.

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* For references 1-4, values are derived by comparative experiments with invariable pendulums, the value for Washington taken as 980.111. For the latter see Appendix 5 of the Coast and Geodetic Survey Report for 1901.

TABLE 86.

SUMMARY OF RESULTS OF THE VALUE OF GRAVITY (g) AT STATIONS IN THE UNITED STATES AND ALASKA.*

Station.	Latitude.	Longitude.	Elevation.	g observed.
	° ′ ″	° ′ ″	Metres.	cm./sec.^{2}
Calais, Me..	45 11 11	67 16 54	38	980.630
Boston, Mass.	42 21 33	71 03 50	22	980.395
Cambridge, Mass.	42 22 48	71 07 45	14	980.397
Worcester, Mass.	42 16 29	71 48 28	170	980.323
New York, N. Y.	40 48 27	73 57 43	38	980.266
Princeton, N. J. .	40 20 57	74 39 28	64	980.177
Philadelphia, Pa.	39 57 06	75 11 40	16	980.195
Ithaca, N. Y.	42 27 04	76 29 00	247	980.299
Baltimore, Md.	39 17 50	76 37 30	30	980.096
Washington, C. & G. S.	38 53 13	77 00 32	14	980.111
Washington, Smithsonian	38 53 20	77 01 32	10	980.113
Charlottesville, Va.	38 02 01	78 30 16	166	979.937
Deer Park, Md.	39 25 02	79 19 50	770	979.934
Charleston, S. C.	32 47 14	79 56 03	6	979.545
Cleveland, Ohio	41 30 22	81 36 38	210	980.240
Key West, Fla.	24 33 33	81 48 25	1	978.969
Atlanta, Ga.	33 44 58	84 23 18	324	979.523
Cincinnati, Ohio	39 08 20	84 25 20	245	980.003
Terre Haute, Ind.	39 28 42	87 23 49	151	980.071
Chicago, Ill.	41 47 25	87 36 03	182	980.277
Madison, Wis. (Univ. of Wis.)	43 04 35	89 24 00	270	980.364
New Orleans, La.	29 56 58	90 04 14	2	979.323
St. Louis, Mo.	38 38 03	90 12 13	154	980.000
Little Rock, Ark.	34 44 57	92 16 24	89	979.720
Kansas City, Mo.	39 05 50	94 35 21	278	979.989
Galveston, Tex.	29 18 12	94 47 29	3	979.271
Austin, Texas (University)	30 17 11	97 44 14	189	979.282
Austin, Texas (Capitol)	30 16 30	97 44 16	170	979.287
Ellsworth, Kan.	38 43 43	98 13 32	469	979.925
Laredo, Tex.	27 30 29	99 31 12	129	979.081
Wallace, Kan.	38 54 44	101 35 26	1005	979.754
Colorado Springs, Col.	38 50 44	104 49 02	1841	979.489
Denver, Col.	39 40 36	104 56 55	1638	979.608
Pike's Peak, Col.	38 50 20	105 02 02	4293	978.953
Gunnison, Col.	38 32 33	106 56 02	2340	979.341
Grand Junction, Col.	39 04 09	108 33 56	1398	979.632
Green River, Utah	38 59 23	110 09 56	1243	979.635
Grand Canyon, Wyo.	44 43 16	110 29 44	2386	979.898
Norris Geyser Basin, Wyo.	44 44 09	110 42 02	2276	979.949
Lower Geyser Basin, Wyo.	44 33 21	110 48 08	2200	979.931
Pleasant Valley Jct., Utah.	39 50 47	111 00 46	2191	979.511
Salt Lake City, Utah	40 46 04	111 53 46	1322	979.802
Ft. Egbert, Eagle, Alaska	64 47 22	141 12 24	174	982.182

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* All the values in this table depend on relative determination of gravity and an adopted value for gravity at Washington (Coast and Geodetic Survey Office) of 980.111. This adopted value was the result of the determination in 1900 of the relative value of gravity at Potsdam and at Washington. See footnote on previous page.

LENGTH OF THE SECONDS PENDULUM.

TABLE 87. — Length of Seconds Pendulum at Sea Level for Different Latitudes.*

Latitude.	Length in centimetres.	Log.	Length in inches.	Log.	Latitude.	Length in centimetres.	Log.	Length in inches.	Log.
0	99.0910	1.996034	39.0121	1.591200	**50**	99.4014	1.997393	39.1344	1.592558
5	.0950	6052	.0137	1217	55	.4459	7587	.1520	2753
10	.1079	6104	.0184	1270	60	.4876	7770	.1683	2935
15	.1265	6190	.0261	1356	65	.5255	7935	.1832	3100
20	.1529	6306	.0365	1471	70	.5581	8077	.1960	3242
25	99.1855	1.996448	39.0493	1.591614	**75**	99.5845	1.998192	39.2065	1.593358
30	.2234	6614	.0642	1779	80	.6040	8277	.2141	3442
35	.2651	6796	.0806	1962	85	.6160	8329	.2188	3494
40	.3096	6991	.0982	2157	90	.6200	8347	.2204	3512
45	.3555	7192	.1163	2357					

* Calculated from force of gravity table by the formula $l = g/\pi^2$. For each 100 feet of elevation subtract 0.000596 centimetres, or 0.000235 inches, or .0000196 feet.

TABLE 88. — Length of the Seconds Pendulum.*

Date of determination.	Number of observation stations.	Range of latitude included by the stations.	Length of pendulum in metres for latitude ϕ.	Corresponding length of pendulum for lat. 45°	Reference.
1799	15	From +67° 05′ to −33° 56′	$0.990631 + .005637 \sin^2\phi$	0.993450	1
1816	31	“ +74° 53′ “ −51° 21′	$0.990743 + .005466 \sin^2\phi$	0.993976	2
1821	8	“ +38° 40′ “ −60° 45′	$0.990880 + .005340 \sin^2\phi$	0.993550	3
1825	25	“ +79° 50′ “ −12° 59′	$0.990977 + .005142 \sin^2\phi$	0.993548	4
1827	41	“ +79° 50′ “ −51° 35′	$0.991026 + .005072 \sin^2\phi$	0.993562	5
1829	5	“ 0° 0′ “ +67° 04′	$0.990555 + .005679 \sin^2\phi$	0.993395	6
1830	49	“ +79° 51′ “ −51° 35′	$0.991017 + .005087 \sin^2\phi$	0.993560	7
1833	—	“ — “ —	$0.990941 + .005142 \sin^2\phi$	0.993512	8
1869	51	“ +79° 50′ “ −51° 35′	$0.990970 + .005185 \sin^2\phi$	0.993554†	9
1876	73	“ +79° 50′ “ −62° 56′	$0.991011 + .005105 \sin^2\phi$	0.993563	10
1884	123	“ +79° 50′ “ −62° 56′	$0.990918 + .005262 \sin^2\phi$	0.993549	11
Combining the above results			$0.990910 + .005290 \sin^2\phi$	0.993555	12

1 Laplace: “Traité de Mécanique Céleste,” T. 2, livre 3, chap. 5, sect. 42.

2 Mathieu: “Sur les expériences du pendule;” in “Connaissance des Temps 1816.” Additions, pp. 314–341, p. 332.

3 Biot et Arago: “Recueil d'Observations géodésiques, etc.” Paris, 1821, p. 575.

4 Sabine: “An Account of Experiments to determine the Figure of the Earth, etc., by Sir Edward Sabine.” London, 1825, p. 352.

5 Saigey: “Comparaison des Observations du pendule à diverses latitudes; faites par MM. Biot, Kater, Sabine, de Freycinet, et Duperry;” in “Bulletin des Sciences Mathématiques, etc.,” T. 1, pp. 31–43, and 171–184. Paris, 1827.

6 Pontécoulant: “Théorie analytique du Système du monde,” Paris, 1829, T. 2, p. 466.

7 Airy: “Figure of the Earth;” in “Encyc. Met.” 2d Div. vol. 3, p. 230.

8 Poisson: “Traité de Mécanique,” T. 1, p. 377; “Connaissance des Temps,” 1834, pp. 32–33; and Puissant: “Traité de géodésie,” T. 2, p. 464.

9 Unferdinger: “Das Pendel als geodätisches Instrument;” in Grunert's “Archiv,” 1869, p. 316.

10 Fischer: “Die Gestalt der Erde und die Pendelmessungen;” in “Ast. Nach.” 1876, col. 87.

11 Helmert: “Die mathematischen und physikalischen Theorieen der höheren Geodäsie, von Dr. F. R. Helmert,” II. Theil. Leipzig, 1884, p. 241.

12 Harkness.

* The data here given with regard to the different determinations which have been made of the length of the seconds pendulum are quoted from Harkness (Solar Parallax and its Related Constants, Washington, 1891).

† Calculated from a logarithmic expression given by Unferdinger.

TABLE 89.

MISCELLANEOUS DATA WITH REGARD TO THE EARTH AND PLANETS.*

Length of the seconds pendulum at sea level $=l=39.012540+0.208268\sin^2\phi$ inches.
$=3.251045+0.017356\sin^2\phi$ feet.
$=0.9909910+0.005290\sin^2\phi$ metres.

Acceleration produced by gravity per second per second mean solar time . . . $=g=32.086528+0.171293\sin^2\phi$ feet.
$=977.9886+5.2210\sin^2\phi$ centimetres.

	Clarke Spheroid.	U. S. C. & G. Survey.
Equatorial radius	$=a=6378206$ metres; 3963.225 miles.	6378388 ± 18 metres; 3963.339 miles.
Polar semi-diameter	$=b=6356584$ metres; 3949.790 miles.	6356909 metres; 3949.992 miles.
Reciprocal of flattening	$=\dfrac{a}{a-b}=295.0$	297.0 ± 0.5
Square of eccentricity	$=e^2=\dfrac{a^2-b^2}{a^2}=0.006768658$	$0.0067237\pm0.0000120.$

Difference between geographical and geocentric latitude $=\phi-\phi'=$
$688.2242''\sin 2\phi-1.1482''\sin 4\phi+0.0026''\sin 6\phi.$

Mean density of the Earth $=5.5247\pm0.0013$ (Burgess Phys. Rev. 1902).

Continental surface density of the Earth $=2.67$ }
Mean density outer ten miles of earth's crust $=2.40$ } Harkness.

Moments of inertia of the Earth; the principal moments being taken as A, B, and C, and C the greater:

$$\frac{C-A}{C}=0.003326521=\frac{1}{306.259};$$
$$C-A=0.001064767\,Ea^2;$$
$$A=B=0.325029\,Ea^2;$$
$$C=0.326094\,Ea^2;$$

where E is the mass of the Earth and a its equatorial semidiameter.

Length of sidereal year $=365.2563578$ mean solar days;
$=365$ days 6 hours 9 minutes 9.314 seconds.

Length of tropical year $=365.242199870-0.0000062124\dfrac{t-1850}{100}$ mean solar days;
$=365$ days 5 hours 48 minutes $\left(46.069-0.53675\dfrac{t-1850}{100}\right)$ seconds.

Length of sidereal month
$=27.321661162-0.00000026240\dfrac{t-1800}{100}$ days;
$=27$ days 7 hours 43 minutes $\left(11.524-0.022671\dfrac{t-1800}{100}\right)$ seconds.

Length of synodical month
$=29.530588435-0.00000030696\dfrac{t-1800}{100}$ days;
$=29$ days 12 hours 44 minutes $\left(2.841-0.026522\dfrac{t-1800}{100}\right)$ seconds.

Length of sidereal day $=86164.09965$ mean solar seconds.

N. B.—The factor containing t in the above equations (the epoch at which the values of the quantities are required) may in all ordinary cases be neglected.

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* Mostly from Harkness, "Solar Parallax and Allied Constants."

MISCELLANEOUS DATA WITH REGARD TO THE EARTH AND PLANETS.

Masses of the Planets.

Reciprocals of the masses of the planets relative to the sun and the mass of the moon relative to the Earth.

Mercury = 6000000
Venus = 408000
Earth * = 329390
Mars = 3093500
Jupiter = 1047.35
Saturn = 3501.6
Uranus = 22869
Neptune = 19700

Moon = 81.45

Mean distance from earth to sun = 92900000 miles = 149500000 kilometres.

Eccentricity of the earth's orbit = e =

$$0.01675104 - 0.0000004180\,(t-1900) - 0.000000126\left(\frac{t-1900}{100}\right)^2.$$

Solar parallax = 8.7997″ ± 0.003 (Weinberg, A. N. 165, 1904);
8.807 ± 0.0027 (Hinks, Eros, 7);
8.799 (Samson, Jupiter satellites; Harvard observations).

Lunar parallax = 3422.68″.

Mean distance from earth to moon = 60.2669 terrestrial radii;
= 238854 miles;
= 384393 kilometres.

Lunar inequality of the earth = L = 6.454″.

Parallactic inequality of the moon = Q = 124.80″.

Mean motion of moon's node in 365.25 days = $\mu = -19^\circ\,21'\,19.6191'' + 0.14136''\left(\frac{t-1800}{100}\right)$

Eccentricity and inclination of the moon's orbit = e_2 = 0.05490807.

Delaunay's $\gamma = \sin \frac{1}{2} I = 0.044886793$.

$I = 5^\circ\,08'\,43.3546''$.

Constant of nutation = 9.2′.

Constant of aberration = 20.4962 ± 0.006 (Weinberg, l. c.).†

Time taken by light to traverse the mean radius of the earth's orbit
= 498.82 ± 0.1 seconds (Weinberg);
= 498.64 (Samson).

Velocity of light = 186330 miles per second (Weinberg);
= 299870 ± 0.03 kilometres per second.

General precession = $50.2564'' + 0.000222\,(t-1900)$.

Obliquity of the ecliptic = $23^\circ\,27'\,8.26'' - 0.4684\,(t-1900)$.

Gravitation constant = 666.07×10^{-10} cm^3/gr. sec^2 ± 0.16×10^{-10}.

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* Earth + moon.

† Recent work of Doolittle's and others indicates a value not less than 20.51.

TABLE 90.

TERRESTRIAL MAGNETISM.

Secular Change of Declination.

Changes in the magnetic declination between 1810, the date of the earliest available observations, and 1910, for one or more places in each state and territory.

State.	Station.	1810	1820	1830	1840	1850	1860	1870	1880	1890	1900	1910
		°	°	°	°	°	°	°	°	°	°	°
Ala.	Montgomery	5.6E	5.8E	5.8E	5.6E	5.4E	5.0E	4.5E	3.9E	3.2E	2.8E	2.9E
Alas.	Sitka	–	–	–	–	–	28.7E	29.0E	29.3E	29.5E	29.7E	30.2E
	Kodiak	–	–	–	–	–	26.1E	25.6E	25.1E	24.7E	24.4E	24.1E
	Unalaska	–	–	–	–	–	20.4E	20.1E	19.6E	19.0E	18.3E	17.5E
	St. Michael	–	–	–	–	–	–	–	24.7E	23.1E	22.1E	21.4E
Ariz.	Holbrook	–	–	–	–	13.6E	13.7E	13.8E	13.7E	13.4E	13.5E	13.9E
	Prescott	–	–	–	–	13.3E	13.5E	13.7E	13.6E	13.5E	13.7E	14.3E
Ark.	Little Rock	8.6E	8.8E	9.0E	9.0E	8.8E	8.6E	8.2E	7.6E	7.0E	6.6E.	6.9E
Cal.	Los Angeles	12.1E	12.6E	13.2E	13.6E	14.0E	14.2E	14.4E	14.6E	14.6E	14.9E	15.5E
	San José	15.0E	15.5E	16.0E	16.4E	16.8E	17.1E	17.3E	17.5E	17.5E	17.8E	18.5E
Cal.	Redding	15.6E	16.1E	16.6E	17.0E	17.4E	17.8E	18.1E	18.2E	18.3E	18.6E	19.3E
Colo.	Pueblo	–	–		–	13.8E	13.8E	13.8E	13.5E	13.0E	12.9E	13.3E
	Glenwood Sp.	–	–	–	–	16.1E	16.2E	16.3E	16.1E	15.7E	15.6E	16.1E
Conn.	Hartford	5.1W	5.6W	6.1W	6.8W	7.5W	8.2W	8.7W	9.4W	9.8W	10.4W	11.0W
Del.	Dover	1.6W	1.9W	2.3W	2.8W	3.4W	4.0W	4.7W	5.3W	5.9W	6.4W	7.0W
D. C.	Washington	0.5E	0.3E	0.0	0.5W	1.0W	1.7W	2.4W	3.0W	3.6W	4.2W	4.7W
Fla.	Jacksonville	5.1E	5.1E	4.9E	4.6E	4.2E	3.7E	3.1E	2.4E	1.8E	1.3E	1.2E
	Pensacola	7.7E	7.8E	7.7E	7.5E	7.2E	6.8E	6.2E	5.6E	5.0E	4.5E	4.4E
	Tampa	6.4E	6.2E	5.9E	5.5E	5.0E	4.5E	3.9E	3.3E	2.8E	2.3E	2.0E
Ga.	Macon	5.9E	5.9E	5.7E	5.4E	5.0E	4.5E	3.9E	3.2E	2.6E	2.1E	2.0E
Haw.	Honolulu	–	–	–	–	9.4E	9.4E	9.5E	9.8E	10.1E	10.4E	10.6E
Idaho	Pocatello	–	–	–	–	17.4E	17.7E	17.8E	17.9E	17.7E	17.8E	18.4E
	Boise	–	–	–	–	18.0E	18.4E	18.6E	18.7E	18.6E	18.8E	19.4E
Ill.	Bloomington	6.3E	6.5E	6.6E	6.5E	6.3E	5.9E	5.4E	4.7E	4.1E	3.6E	3.4E
Ind.	Indianapolis	5.0E	5.1E	5.0E	4.7E	4.4E	3.8E	3.2E	2.6E	2.0E	1.4E	1.1E
Ia.	Des Moines	–	10.2E	10.4E	10.5E	10.4E	10.2E	9.7E	9.1E	8.4E	7.9E	8.1E
Kans.	Emporia	–	–	–	–	11.6E	11.5E	11.2E	10.7E	10.1E	9.8E	10.1E
	Ness City	–	–	–	–	12.4E	12.4E	12.2E	11.9E	11.4E	11.1E	11.4E
Ky.	Lexington	4.5E	4.5E	4.4E	4.1E	3.6E	3.1E	2.5E	1.9E	1.2E	0.7E	0.5E
	Princeton	6.8E	7.0E	7.0E	6.8E	6.5E	6.1E	5.6E	5.0E	4.3E	3.8E	3.7E
La.	Alexandria	8.4E	8.7E	8.8E	8.8E	8.7E	8.4E	8.0E	7.4E	6.9E	6.6E	6.8E
Me.	Eastport	13.6W	14.4W	15.2W	16.0W	17.0W	17.7W	18.2W	18.6W	18.7W	19.0W	19.4W
	Portland	9.0W	9.6W	10.3W	11.0W	11.6W	12.3W	12.8W	13.4W	13.9W	14.4W	14.8W
Md.	Baltimore	0.9W	1.1W	1.4W	1.9W	2.4W	3.1W	3.8W	4.4W	5.0W	5.6W	6.1W
Mass.	Boston	7.3W	7.8W	8.4W	9.1W	9.8W	10.5W	11.0W	11.5W	12.0W	12.6W	13.1W
Mass.	Pittsfield	5.7W	6.1W	6.7W	7.4W	8.1W	8.7W	9.3W	10.0W	10.4W	11.0W	11.5W
Mich.	Marquette	–	6.7E	6.7E	6.5E	6.0E	5.4E	4.6E	3.8E	3.0E	2.3E	2.0E
	Lansing	–	4.2E	4.1E	3.8E	3.3E	2.8E	2.1E	1.3E	0.5E	0.0E	0.4E
Minn.	Northome	–	10.4E	10.7E	10.8E	10.7E	10.4E	10.0E	9.3E	8.6E	8.0E	8.1E
	Mankato	–	11.3E	11.6E	11.7E	11.6E	11.3E	10.9E	10.4E	9.5E	9.0E	9.1E

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* Tables have been compiled from United States Magnetic Tables and Magnetic Charts for 1905, published by the Coast and Geodetic Survey in 1908.

Table 90 (*continued*).

TERRESTRIAL MAGNETISM (*continued*).

Secular Change of Declination (*continued*).

State.	Station.	1810	1820	1830	1840	1850	1860	1870	1880	1890	1900	1910
		°	°	°	°	°	°	°	°	°	°	°
Miss.	Jackson	8.2E	8.4E	8.5E	8.4E	8.2E	7.9E	7.5E	6.9E	6.4E	6.0E	6.2E
Mo.	Sedalia	–	10.0E	10.2E	10.2E	10.1E	9.8E	9.4E	8.7E	8.0E	7.6E	7.9E
Mont.	Forsyth	–	–	–	18.2E	18.5E	18.6E	18.6E	18.4E	17.9E	17.8E	18.3E
	Helena	–	–	–	18.9E	19.3E	19.6E	19.8E	19.6E	19.4E	19.5E	20.0E
Nebr.	Hastings	–	11.6E	12.0E	12.1E	12.1E	12.0E	11.7E	11.2E	10.5E	10.2E	10.5E
Nebr.	Alliance	–	–	–	–	15.4E	15.4E	15.3E	14.8E	14.3E	14.2E	14.5E
Nev.	Elko	–	–	–	–	17.3E	17.6E	17.7E	17.7E	17.6E	17.8E	18.3E
	Hawthorne	–	–	–	–	16.3E	16.6E	16.9E	17.0E	17.0E	17.3E	17.8E
N. H.	Hanover	7.1W	7.5W	8.2W	8.9W	9.8W	10.5W	11.1W	11.6W	12.0W	12.5W	13.0W
N. J.	Trenton	2.8W	3.1W	3.5W	4.1W	4.7W	5.4W	6.0W	6.7W	7.2W	7.8W	8.4W
N. M.	Santa Rosa	–	–	–	–	12.7E	12.8E	12.7E	12.5E	12.1E	12.0E	12.4E
	Laguna	–	–	–	–	13.4E	13.6E	13.6E	13.4E	13.0E	13.0E	13.5E
N. Y.	Albany	5.6W	5.8W	6.3W	6.9W	7.6W	8.4W	9.1W	9.8W	10.2W	10.8W	11.4W
	Elmira	2.2W	2.4W	2.8W	3.3W	4.0W	4.8W	5.4W	6.3W	7.0W	7.6W	8.1W
N. C.	Newbern	1.7E	1.6E	1.3E	0.8E	0.3E	0.3W	1.0W	1.6W	2.2W	2.8W	3.3W
N. C.	Salisbury	3.9E	3.8E	3.6E	3.2E	2.7E	2.1E	1.5E	0.8E	0.2E	0.4W	0.7W
N. Dak.	Jamestown	–	–	–	–	14.5E	14.3E	14.0E	13.5E	12.7E	12.4E	12.8E
	Dickinson	–	–	–	–	17.6E	17.6E	17.4E	17.0E	16.4E	16.2E	16.6E
Ohio	Columbus	3.4E	3.4E	3.2E	2.9E	2.4E	1.8E	1.2E	0.6E	0.0	0.7W	1.1W
Okla.	Okmulgee	–	–	–	–	10.2E	10.1E	9.8E	9.4E	8.8E	8.5E	8.9E
Okla.	Enid	–	–	–	–	11.2E	11.1E	10.9E	10.5E	9.9E	9.7E	10.1E
Oreg.	Sumpter	–	–	–	–	19.3E	19.7E	20.0E	20.2E	20.2E	20.4E	21.0E
	Detroit	16.7E	17.4E	18.0E	18.6E	19.2E	19.7E	20.1E	20.4E	20.5E	20.8E	21.5E
Pa.	Philadelphia	2.2W	2.4W	2.8W	3.4W	4.1W	4.8W	5.5W	6.3W	6.8W	7.4W	8.0W
	Altoona	0.5W	0.6W	0.9W	1.3W	1.8W	2.4W	3.1W	3.8W	4.5W	5.1W	5.6W
P. R.	San Juan	–	–	–	–	–	–	–	–	–	1.0W	2.0W
R. I.	Newport	6.6W	7.1W	7.7W	8.4W	9.1W	9.8W	10.3W	10.8W	11.3W	11.9W	12.4W
S. C.	Columbia	4.4E	4.3E	4.1E	3.7E	3.2E	2.7E	2.1E	1.4E	0.8E	0.2E	0.1W
S. D.	Huron	–	–	–	13.1E	13.1E	12.9E	12.6E	12.1E	11.4E	11.1E	11.4E
	Rapid City	–	–	–	–	16.4E	16.4E	16.3E	15.8E	15.3E	15.1E	15.4E
Tenn.	Chattanooga	5.3E	5.3E	5.1E	4.8E	4.4E	3.9E	3.3E	2.6E	2.0E	1.5E	1.3E
	Huntington		7.4E	7.4E	7.3E	7.0E	6.6E	6.1E	5.5E	4.9E	4.4E	4.3E
Tex.	Houston	–	8.9E	9.2E	9.3E	9.3E	9.2E	8.9E	8.5E	7.9E	7.7E	8.1E
	San Antonio	–	–	9.6E	9.8E	9.9E	9.8E	9.6E	9.3E	8.9E	8.7E	9.1E
	Pecos	–	–	10.8E	11.0E	11.1E	11.1E	11.0E	10.8E	10.4E	10.3E	10.7E
Tex.	Floydada	–	–	–	–	11.3E	11.3E	11.2E	10.9E	10.4E	10.3E	10.7E
Utah	Salt Lake		–	–	–	16.4E	16.6E	16.7E	16.5E	16.3E	16.5E	17.0E
Vt.	Rutland	6.8W	7.2W	7.8W	8.5W	9.2W	10.0W	10.6W	11.2W	11.6W	12.1W	12.7W
Va.	Richmond	0.8E	0.6E	0.3W	0.1W	0.6W	1.2W	1.8W	2.5W	3.1W	3.7W	4.2W
	Lynchburg	1.9E	1.8E	1.6E	1.2E	0.8E	0.2E	0.5W	1.2W	1.8W	2.4W	2.8W
Wash.	Wilson Creek					21.3E	21.6E	21.9E	21.9E	22.1E	22.4E	22.9E
	Seattle	19.1E	19.7E	20.3E	20.8E	21.3E	21.8E	22.1E	22.3E	22.6E	23.0E	23.5E
W. Va.	Charleston	2.3E	2.2E	2.0E	1.6E	1.1E	0.5E	0.2W	0.9W	1.5W	2.1W	2.6W
Wis.	Madison	–	8.6E	8.7E	8.6E	8.3E	7.8E	7.2E	6.4E	5.6E	5.0E	4.9E
Wyo.	Douglas	–	–	–	–	15.8E	16.0E	16.0E	15.8E	15.4E	15.3E	15.7E
	Green River	–	–	–	–	16.8E	17.0E	17.0E	16.9E	16.6E	16.6E	17.0E

TERRESTRIAL MAGNETISM (*continued*).

TABLE 91.—Dip or Inclination.

This table gives for the epoch January 1, 1905, the values of the magnetic dip, I, corresponding to the longitudes west of Greenwich in the heading and the north latitudes in the first column.

	65°	70°	75°	80°	85°	90°	95°	100°	105°	110°	115°	120°	125°
°	°	°	°	°	°	°	°	°	°	°	°	°	°
19	-	-	48.8	49.1	47.5	46.3	44.8	44.2	43.9	-	-	-	-
21	-	-	51.0	51.1	50.0	49.3	48.2	47.0	46.5	-	-	-	-
23	-	-	53.7	53.0	52.4	51.8	50.7	49.6	48.8	48.2	-	-	-
25	-	-	56.3	56.0	55.0	54.5	53.2	52.4	51.5	50.6	49.8	48.3	-
27	-	-	58.9	58.1	57.6	56.8	55.6	54.7	53.9	53.1	52.6	51.0	-
29	-	60.7	61.0	60.2	59.8	58.9	58.2	57.2	56.2	55.5	54.8	53.7	-
31	-	63.0	63.1	62.6	62.0	61.3	60.6	59.6	58.7	57.7	56.7	56.0	-
33	-	65.0	65.0	64.6	64.0	63.5	62.7	62.0	61.0	59.8	58.9	58.1	-
35	-	67.0	66.9	66.5	66.0	65.6	64.9	63.7	62.7	62.3	61.0	60.2	-
37	-	68.6	68.9	68.6	68.2	67.7	66.9	66.2	65.1	64.6	62.9	62.2	-
39	-	70.3	70.6	70.4	70.2	69.7	68.8	68.1	67.2	66.1	65.0	64.0	62.8
41	-	71.8	72.2	72.2	71.9	71.4	70.8	69.8	68.9	67.8	66.8	65.6	64.7
43	-	73.5	73.9	74.1	73.8	73.3	72.6	71.6	70.7	69.6	68.6	67.5	66.3
45	74.4	74.8	75.6	75.5	75.4	75.0	74.3	73.6	72.4	71.5	70.3	69.2	68.1
47	75.7	76.2	76.9	76.8	76.9	76.8	76.0	75.2	74.2	73.0	71.8	70.8	69.9
49	76.8	78.1	78.2	78.3	78.7	78.1	77.5	76.8	75.8	74.5	73.5	72.3	71.4

TABLE 92.—Secular Change of Dip.

Values of magnetic dip for places designated by the north latitudes and longitudes west of Greenwich in the first two columns for January 1st of the years in the heading. The degrees are given in the third column and minutes in the succeeding columns.

Latitude.	Longitude.		1855	1860	1865	1870	1875	1880	1885	1890	1895	1900	1905	1910
°	°	°	′	′	′	′	′	′	′	′	′	′	′	′
25	80	55+	49	49	48	46	43	40	35	35	39	48	60	77
25	110	49+	08	20	30	39	46	55	61	68	76	86	96	106
30	83	60+	66	70	73	74	73	67	57	51	53	63	78	96
30	100	57+	44	49	58	67	70	65	60	61	68	77	90	105
30	115	54+	53	62	69	71	70	72	75	79	85	91	96	101
35	80	66+	57	58	57	54	45	35	26	21	20	22	30	38
35	90	65+	65	59	51	44	37	32	26	25	25	27	36	48
35	105	62+	-	-	-	32	30	24	24	24	28	34	42	50
35	120	60+	03	06	08	08	07	06	08	11	13	14	12	08
40	75	71+	82	82	78	73	65	55	43	33	27	24	24	24
40	90	70+	30	31	34	37	36	32	29	26	25	26	30	36
40	105	67+	-	-	-	56	53	51	51	51	52	56	60	65
40	120	64+	-	48	46	44	44	44	44	44	45	45	48	48
45	65	74+	116	110	101	92	80	68	57	46	35	28	24	20
45	75	75+	103	99	95	90	85	73	62	53	43	38	36	34
45	90	74+	81	81	81	79	77	75	68	63	61	59	60	60
45	105	72+	-	-	-	-	-	22	20	20	21	22	24	27
45	122.5	68+	35	34	37	40	40	39	37	34	30	26	24	20
49	92	78+	26	25	24	22	20	20	15	12	11	09	06	04
49	120	72+	-	26	24	22	22	19	20	19	19	19	18	16

TERRESTRIAL MAGNETISM *(continued).*

TABLE 93.—Horizontal Intensity.

This table gives for the epoch January 1, 1905, the horizontal intensity, H, expressed in C. G. S. units, corresponding to the longitudes in the heading and the latitudes in the first column.

	65°	70°	75°	80°	85°	90°	95°	100°	105°	110°	115°	120°	125°
°													
19	-	-	.307	.314	.319	.322	.328	.332	.331				
21	-	-	.301	.309	.314	.316	.320	.324	.324				
23	-	-	.293	.303	.305	.309	.312	.315	.317	.320			
25	-	-	.284	.292	.295	.299	.304	.307	.308	.309	.312	.304	
27	-	-	.274	.280	.286	.289	.296	.298	.300	.303	.306	.298	
29	-	.257	.262	.269	.276	.281	.286	.289	.292	.294	.297	.291	
31	-	.246	.251	.256	.263	.269	.274	.277	.282	.284	.285	.282	
33	-	.233	.239	.245	.251	.257	.262	.266	.270	.273	.274	.274	
35	-	.220	.225	.232	.240	.242	.248	.253	.256	.259	.262	.265	
37	-	.208	.209	.218	.222	.226	.232	.238	.245	.246	.252	.251	
39	-	.197	.198	.203	.206	.212	.217	.224	.229	.237	.240	.242	.245
41	-	.184	.185	.186	.192	.196	.202	.207	.216	.223	.228	.240	.236
43	-	.170	.170	.169	.175	.178	.187	.194	.201	.210	.215	.222	.226
45	.161	.157	.155	.156	.157	.162	.169	.177	.190	.192	.199	.208	.215
47	.145	.144	.140	.142	.142	.150	.152	.161	.170	.180	.188	.196	.201
49	.131	.129	.125	.126	.124	.129	.138	.146	.153	.165	.175	.182	.187

TABLE 94.—Secular Change of Horizontal Intensity.

Values of horizontal intensity in C. G. S. units for places designated by the latitude and longitude in the first two columns for January 1 of the years in the heading.

Latitude.	Longitude.	1855	1860	1865	1870	1875	1880	1885	1890	1895	1900	1905	1910
°	°												
25	80	.3099	.3086	.3073	.3057	.3042	.3025	.3008	.2990	.2970	.2949	.2920	.2890
25	110	.3229	.3218	.3204	.3189	.3170	.3155	.3143	.3130	.3117	.3104	.3090	.3075
30	83	.2803	.2795	.2788	.2780	.2772	.2763	.2752	.2740	.2725	.2706	.2680	.2644
30	100	–	–	.2961	.2942	.2924	.2907	.2891	.2877	.2865	.2850	.2830	.2804
30	115	.3040	.3026	.3011	.2996	.2979	.2964	.2952	.2940	.2929	.2920	.2910	.2898
35	80	.2384	.2379	.2374	.2369	.2367	.2363	.2359	.2352	.2347	.2337	.2320	.2296
35	90	–	–	–	.2462	.2462	.2461	.2458	.2455	.2447	.2437	.2430	.2399
35	105	–	–	–	–	.2620	.2608	.2599	.2590	.2583	.2573	.2560	.2544
35	120	–	–	–	.2720	.2707	.2695	.2683	.2672	.2663	.2656	.2650	.2644
40	75	.1880	.1883	.1891	.1902	.1911	.1919	.1925	.1930	.1931	.1928	.1920	.1909
40	90	–	.2086	.2082	.2079	.2076	.2075	.2074	.2072	.2068	.2060	.2050	.2036
40	105	–	–	–	.2272	.2266	.2261	.2257	.2253	.2248	.2240	.2230	.2217
40	120	–	–	–	.2429	.2420	.2412	.2406	.2399	.2392	.2386	.2380	.2379
45	65	.1504	.1514	.1525	.1537	.1553	.1567	.1578	.1589	.1600	.1608	.1610	.1610
45	75	.1483	.1485	.1488	.1495	.1506	.1516	.1527	.1538	.1546	.1550	.1550	.1554
45	90	–	.1635	.1633	.1631	.1628	.1626	.1624	.1623	.1624	.1623	.1620	.1616
45	105	–	–	–	.1920	.1919	.1918	.1916	.1913	.1910	.1906	.1900	.1892
45	122.5	.2175	.2170	.2162	.2153	.2145	.2135	.2127	.2121	.2117	.2115	.2115	.2115
49	92	.1332	.1330	.1328	.1324	.1321	.1319	.1318	.1318	.1321	.1324	.1330	.1335
49	120	.1841	.1841	.1840	.1839	.1836	.1831	.1826	.1821	.1819	.1820	.1820	.1824

TERRESTRIAL MAGNETISM (*continued*).

TABLE 95. — Total Intensity.

This table gives for the epoch January 1, 1905, the values of total intensity, F, expressed in C. G. S. units corresponding to the longitudes in the heading and the latitudes in the first column.

	65°	70°	75°	80°	85°	90°	95°	100°	105°	110°	115°	120°	125°
°													
19	–	–	.466	.480	.472	.466	.462	.463	.459	–	–	–	–
21	–	–	.478	.492	.489	.485	.480	.475	.471	–	–	–	–
23	–	–	.495	.504	.500	.500	.493	.486	.481	.480	–	–	–
25	–	–	.512	.522	.514	.515	.507	.503	.495	.487	.483	.457	–
27	–	–	.530	.530	.534	.528	.524	.516	.509	.505	.504	.474	–
29	–	.525	.540	.541	.549	.544	.543	.534	.525	.519	.515	.492	–
31	–	.542	.555	.556	.560	.560	.558	.547	.543	.531	.519	.504	–
33	–	.551	.566	.571	.572	.576	.571	.567	.557	.543	.530	.518	–
35	–	.563	.574	.582	.590	.586	.584	.571	.558	.557	.540	.533	–
37	–	.570	.581	.598	.598	.596	.591	.590	.582	.573	.553	.538	–
39	–	.584	.596	.605	.608	.611	.600	.600	.591	.585	.568	.552	.536
41	–	.589	.605	.608	.618	.614	.614	.600	.600	.590	.579	.581	.552
43	–	.599	.613	.617	.627	.619	.625	.614	.608	.602	.589	.580	.562
45	.599	.599	.623	.623	.623	.626	.624	.627	.628	.605	.590	.586	.576
47	.587	.604	.618	.622	.626	.657	.628	.630	.624	.616	.602	.596	.585
49	.574	.626	.611	.621	.633	.626	.638	.639	.624	.617	.616	.599	.588

TABLE 96. — Secular Change of Total Intensity.

Values of total intensity in C. G. S. units for places designated by the latitudes and longitudes in the first two columns for January 1 of the years in the heading. (Computed from Tables 92 and 94.)

Latitude.	Longitude.	1855	1860	1865	1870	1875	1880	1885	1890	1895	1900	1905	1910
°	°												
25	80	.5516	.5493	.5467	.5434	.5400	.5364	.5322	.5290	.5264	.5247	.5222	.5206
25	110	.4935	.4938	.4933	.4925	.4908	.4902	.4891	.4883	.4876	.4873	.4868	.4860
30	83	.5800	.5796	.5790	.5777	.5757	.5720	.5668	.5625	.5600	.5590	.5581	.5559
30	100	–	–	.5583	.5570	.5544	.5499	.5456	.5432	.5427	.5421	.5416	.5405
30	115	.5285	.5280	.5269	.5247	.5215	.5194	.5179	.5167	.5160	.5158	.5151	.5140
35	80	.6089	.6080	.6063	.6038	.5996	.5946	.5900	.5863	.5874	.5830	.5818	.5789
35	90	–	–	–	.5991	.5964	.5942	.5912	.5901	.5882	.5865	.5858	.5852
35	105	–	–	–	–	.5674	.5629	.5610	.5590	.5588	.5585	.5582	.5572
35	120	–	–	–	.5462	.5433	.5406	.5388	.5374	.5361	.5350	.5332	.5309
40	75	.6206	.6216	6220	.6227	.6212	.6182	.6136	.6098	.6070	.6045	.6019	.5985
40	90	–	.6254	.6258	.6264	.6250	.6226	.6208	.6187	.6170	.6151	.6141	.6135
40	105	–	–	–	.6048	.6019	.5997	.5986	.5976	.5967	.5963	.5953	.5940
40	120	–	–	–	.5691	.5670	.5651	.5637	.5620	.5608	.5593	.5590	.5591
45	65	.6188	.6186	.6167	.6152	.6134	.6107	.6077	.6048	.6019	.6005	.5987	.5962
45	75	.6454	.6431	.6413	.6404	.6412	.6363	.6327	.6306	.6266	.6247	.6233	.6235
45	90	–	.6465	.6457	.6434	.6408	.6386	.6330	.6291	.6382	.6264	.6259	.6244
45	105	–	–	–	–	–	.6332	.6314	.6303	.6299	.6392	.6284	.6275
45	122.5	.5956	.5938	.5930	.5918	.5896	.5864	.5834	.5804	.5776	.5754	.5745	.5728
49	92	.6643	.6624	.6604	.6566	.6533	.6523	.6472	.6445	.6451	.6447	.6450	.6456
49	120	–	.6100	.6085	.6071	.6061	.6028	.6017	.5995	.5988	.5992	.5986	.5988

TABLE 97.

AGONIC LINE.

The line of no declination appears to be still moving westward in the United States, but the line of no annual change is only a short distance to the west of it, so that it is probable that the extreme westerly position will soon be reached.

Lat. N.	Longitudes of the agonic line for the years—				
	1800	1850	1875	1890	1905
°	°	°	°	°	°
25	–	–	–	75.5	76.1
30	–	–	–	78.6	79.7
35	–	76.7	79.0	79.9	81.7
6	75.2	77.3	79.7	80.5	82.8
7	76.3	77.7	80.6	82.2	83.5
8	76.7	78.3	81.3	82.6	83.6
9	76.9	78.7	81.6	82.2	83.6
40	77.0	79.3	81.6	82.7	84.0
1	77.9	80.4	81.8	82.8	84.6
2	79.1	81.0	82.6	83.7	84.8
3	79.4	81.2	83.1	84.3	85.0
4	79.8	–	83.3	84.9	85.5
45	–	–	83.6	85.2	86.0
6	–	–	84.2	84.8	86.4
7	–	–	85.1	85.4	86.4
8	–	–	86.0	85.9	86.5
9	–	–	86.5	86.3	87.2

TABLE 98.

PRESSURE OF COLUMNS OF MERCURY AND WATER.

British and metric measures. Correct at 0° C. for mercury and at 4° C. for water.

METRIC MEASURE.			BRITISH MEASURE.		
Cms. of Hg.	Pressure in grammes per sq. cm.	Pressure in pounds per sq. inch.	Inches of Hg.	Pressure in grammes per sq. cm.	Pressure in pounds per sq. inch.
1	13.5956	0.193376	1	34.533	0.491174
2	27.1912	0.386752	2	69.066	0.982348
3	40.7868	0.580128	3	103.598	1.473522
4	54.3824	0.773504	4	138.131	1.964696
5	67.9780	0.966880	5	172.664	2.455870
6	81.5736	1.160256	6	207.197	2.947044
7	95.1692	1.353632	7	241.730	3.438218
8	108.7648	1.547008	8	276.262	3.929392
9	122.3604	1.740384	9	310.795	4.420566
10	135.9560	1.933760	10	345.328	4.911740

Cms. of H_2O.	Pressure in grammes per sq. cm.	Pressure in pounds per sq. inch.	Inches of H_2O.	Pressure in grammes per sq. cm.	Pressure in pounds per sq. inch.
1	1	0.0142234	1	2.54	0.036127
2	2	0.0284468	2	5.08	0.072255
3	3	0.0426702	3	7.62	0.108382
4	4	0.0568936	4	10.16	0.144510
5	5	0.0711170	5	12.70	0.180637
6	6	0.0853404	6	15.24	0.216764
7	7	0.0995638	7	17.78	0.252892
8	8	0.1137872	8	20.32	0.289019
9	9	0.1280106	9	22.86	0.325147
10	10	0.1422340	10	25.40	0.361274

TABLE 99.

REDUCTION OF BAROMETRIC HEIGHT TO STANDARD TEMPERATURE.*

Corrections for brass scale and English measure.		Corrections for brass scale and metric measure.		Corrections for glass scale and metric measure.	
Height of barometer in inches.	*a* in inches for temp. F.	Height of barometer in mm.	*a* in mm. for temp. C.	Height of barometer in mm.	*a* in mm. for temp. C.
15.0	0.00135	**400**	0.0651	**50**	0.0086
16.0	.00145	410	.0668	100	.0172
17.0	.00154	420	.0684	150	.0258
17.5	.00158	430	.0700	200	.0345
18.0	.00163	440	.0716	250	.0431
18.5	.00167	450	.0732	300	.0517
19.0	.00172	460	.0749	350	.0603
19.5	.00176	470	.0765	**400**	0.0689
20.0	0.00181	480	.0781	450	.0775
20.5	.00185	490	.0797	500	.0861
21.0	.00190	**500**	0.0813	520	.0898
21.5	.00194	510	.0830	540	.0934
22.0	.00199	520	.0846	560	.0971
22.5	.00203	530	.0862	580	.1007
23.0	.00208	540	.0878	**600**	0.1034
23.5	.00212	550	.0894	610	.1051
24.0	0.00217	560	.0911	620	.1068
24.5	.00221	570	.0927	630	.1085
25.0	.00226	580	.0943	640	.1103
25.5	.00231	590	.0959	650	.1120
26.0	.00236	**600**	0.0975	660	.1137
26.5	.00240	610	.0992	**670**	0.1154
27.0	.00245	620	.1008	680	.1172
27.5	.00249	630	.1024	690	.1189
28.0	0.00254	640	.1040	700	.1206
28.5	.00258	650	.1056	710	.1223
29.0	.00263	660	.1073	720	.1240
29.2	.00265	670	.1089	730	.1258
29.4	.00267	680	.1105	**740**	0.1275
29.6	.00268	690	.1121	750	.1292
29.8	.00270	**700**	0.1137	760	.1309
30.0	.00272	710	.1154	770	.1327
30.2	0.00274	720	.1170	780	.1344
30.4	.00276	730	.1186	790	.1361
30.6	.00277	740	.1202	800	.1378
30.8	.00279	750	.1218	**850**	0.1464
31.0	.00281	760	.1235	900	.1551
31.2	.00283	770	.1251	950	.1639
31.4	.00285	780	.1267	1000	.1723
31.6	.00287	790	.1283		
		800	.1299		

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* The height of the barometer is affected by the relative thermal expansion of the mercury and the glass, in the case of instruments graduated on the glass tube, and by the relative expansion of the mercury and the metallic inclosing case, usually of brass, in the case of instruments graduated on the brass case. This relative expansion is practically proportional to the first power of the temperature. The above tables of values of the coefficient of relative expansion will be found to give corrections almost identical with those given in the International Meteorological Tables. The numbers tabulated under *a* are the values of *a* in the equation $H_t = H_t' - a(t' - t)$ where H_t is the height at the standard temperature, H_t' the observed height at the temperature t', and $a(t' - t)$ the correction for temperature. The standard temperature is 0° C. for the metric system and 28°.5 F. for the English system. The English barometer is correct for the temperature of melting ice at a temperature of approximately 28°.5 F., because of the fact that the brass scale is graduated so as to be standard at 62° F., while mercury has the standard density at 32° F.

Example.—A barometer having a brass scale gave $H = 765$ mm. at 25° C.; required, the corresponding reading at 0° C. Here the value of *a* is the mean of .1235 and .1251, or .1243; ∴ $a(t' - t) = .1243 \times 25 = 3.11$. Hence $H_0 = 765 - 3.11 = 761.89$.

N. B.—Although *a* is here given to three and sometimes to four significant figures, it is seldom worth while to use more than the nearest two-figure number. In fact, all barometers have not the same values for *a*, and when great accuracy is wanted the proper coefficients have to be determined by experiment.

Table 100.

CORRECTION OF BAROMETER TO STANDARD GRAVITY.

Correction in millimetres for elevation above sea level in first column and height of barometer in top line.

Height above sea level in metres.	Observed height of barometer in millimetres.								
	400	450	500	550	600	650	700	750	800
100							.014	.015	.016
200							.028	.030	.032
300							.041	.044	.047
400							.055	.059	.063
500						.064	.068	.073	.078
600						.077	.082	.088	
700						.090	.096	.102	
800						.103	.109	.117	
900						.115	.123	.131	
1000				.108	.118	.128	.137	.146	
1100				.118	.130	.141	.150		
1200				.129	.142	.154	.164		
1300				.140	.153	.166	.178		
1400				.151	.165	.179	.191		
1500			.147	.162	.176	.191	.205		
1600			.157	.172	.188	.204			
1700			.167	.183	.200	.217			
1800			.177	.194	.212	.230			
1900			.187	.204	.224	.242			
2000		.176	.196	.215	.235	.255			
2100		.185	.206	.226	.247				
2200		.194	.216	.237	.259				
2300		.203	.226	.248	.271				
2400		.212	.236	.259	.283				
2500	.195	.220	.245	.270	.295				
2600	.203	.229	.255						
2700	.211	.238	.265						
2800	.219	.247	.275						
2900	.227	.256	.285						
3000	.235	.265	.294						
3100	.243	.274							
3200	.251	.283							
3300	.259	.292							
3400	.267	.201							
3500	.275	.309							
3600	.283								
3700	.291								
3800	.299								
3900	.307								
4000	.314								

Corrections in hundredths of an inch for elevation above sea level in last column and height of barometer in bottom line.

Observed height of barometer in inches.										Height above sea level in feet.
32	30	28	26	24	22	20	18	16	14	
									1.245	15000
									1.203	14500
								1.340	1.162	14000
								1.292	1.120	13500
								1.244	1.088	13000
							1.345	1.196	1.046	12500
							1.291	1.149	1.004	12000
							1.237	1.101	.962	11500
						1.315	1.184	1.053	.920	11000
						1.255	1.130	1.005	.879	10500
						1.196	1.076	.957	.837	10000
					1.050	1.136	1.022	.909	.795	9500
					.984	1.076	.969	.861	.753	9000
					.918	1.016	.915	.813		8500
					.853	.957	.861	.765		8000
				1.077	.787	.897	.807			7500
				1.005	.721	.837	.753			7000
				.934	.655	.777	.700			6500
				.862	.789	.718				6000
				.790	.724	.658				5500
			.779	.718	.658	.598				5000
			.701	.646	.592					4500
			.623	.574	.526					4000
			.545	.503	.461					3500
		.503	.467	.431	.395					3000
		.419	.389	.359						2500
	.359	.335	.311	.287						2000
	.269	.251	.233	.215						1500
.192	.179	.167	.155							1000
.096	.090	.084	.078							500

TABLE 101.

REDUCTION OF BAROMETER TO STANDARD GRAVITY.*

Reduction to Latitude 45°. — English Scale.

N. B. From latitude 0° to 44° the correction is to be subtracted.
From latitude 90° to 46° the correction is to be added.

Latitude.		Height of the barometer in inches.											
		19	20	21	22	23	24	25	26	27	28	29	30
		Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.
0°	**90°**	0.051	0.053	0.056	0.059	0.061	0.064	0.067	0.069	0.072	0.074	0.077	0.080
5	**85**	0.050	0.052	0.055	0.058	0.060	0.063	0.066	0.068	0.071	0.073	0.076	0.079
6	84	.049	.052	.055	.057	.060	.062	.065	.068	.070	.073	.076	.078
7	83	.049	.052	.054	.057	.059	.062	.065	.067	.070	.072	.075	.077
8	82	.049	.051	.054	.056	.059	.061	.064	.067	.069	.072	.074	.077
9	81	.048	.051	.053	.056	.058	.061	.063	.066	.068	.071	.073	.076
10	**80**	0.048	0.050	0.053	0.055	0.058	0.060	0.063	0.065	0.068	0.070	0.073	0.075
11	79	.047	.049	.052	.054	.057	.059	.062	.064	.067	.069	.072	.074
12	78	.046	.049	.051	.054	.056	.058	.061	.063	.066	.068	.071	.073
13	77	.045	.048	.050	.053	.055	.057	.060	.062	.065	.067	.069	.072
14	76	.045	.047	.049	.052	.054	.056	.059	.061	.063	.066	.068	.071
15	**75**	0.044	0.046	0.048	0.051	0.053	0.055	0.058	0.060	0.062	0.065	0.067	0.069
16	74	.043	.045	.047	.050	.052	.054	.056	.059	.061	.063	.065	.068
17	73	.042	.044	.046	.049	.051	.053	.055	.057	.060	.062	.064	.066
18	72	.041	.043	.045	.047	.050	.052	.054	.056	.058	.060	.062	.065
19	71	.040	.042	.044	.046	.048	.050	.052	.055	.057	.059	.061	.063
20	**70**	0.039	0.041	0.043	0.045	0.047	0.049	0.051	0.053	0.055	0.057	0.059	0.061
21	69	.038	.040	.042	.044	.045	.047	.049	.051	.053	.055	.057	.059
22	68	.036	.038	.040	.042	.044	.046	.048	.050	.052	.054	.056	.057
23	67	.035	.037	.039	.041	.043	.044	.046	.048	.050	.052	.054	.055
24	66	.034	.036	.037	.039	.041	.043	.045	.046	.048	.050	.052	.053
25	**65**	0.033	0.034	0.036	0.038	0.039	0.041	0.043	0.044	0.046	0.048	0.050	0.051
26	64	.031	.033	.034	.036	.038	.039	.041	.043	.044	.046	.048	.049
27	63	.030	.031	.033	.034	.036	.038	.039	.041	.042	.044	.045	.047
28	62	.028	.030	.031	.033	.034	.036	.037	.039	.040	.042	.043	.045
29	61	.027	.028	.030	.031	.032	.034	.035	.037	.038	.039	.041	.042
30	**60**	0.025	0.027	0.028	0.029	0.031	0.032	0.033	0.035	0.036	0.037	0.039	0.040
31	59	.024	.025	.026	.027	.029	.030	.031	.032	.034	.035	.036	.037
32	58	.022	.023	.025	.026	.027	.028	.029	.030	.032	.033	.034	.035
33	57	.021	.022	.023	.024	.025	.026	.027	.028	.029	.030	.031	.032
34	56	.019	.020	.021	.022	.023	.024	.025	.026	.027	.028	.029	.030
35	**55**	0.017	0.018	0.019	0.020	0.021	0.022	0.023	0.024	0.025	0.025	0.026	0.027
36	54	.016	.016	.017	.018	.019	.020	.021	.021	.022	.023	.024	.025
37	53	.014	.015	.015	.016	.017	.018	.018	.019	.020	.021	.021	.022
38	52	.012	.013	.014	.014	.015	.015	.016	.017	.017	.018	.019	.019
39	51	.011	.011	.012	.012	.013	.013	.014	.014	.015	.015	.016	.017
40	**50**	0.009	0.009	0.010	0.010	0.011	0.011	0.012	0.012	0.012	0.013	0.013	0.014
41	49	.007	.007	.008	.008	.009	.009	.009	.010	.010	.010	.011	.011
42	48	.005	.006	.006	.006	.006	.007	.007	.007	.008	.008	.008	.008
43	47	.004	.004	.004	.004	.004	.004	.005	.005	.005	.005	.005	.006
44	46	.002	.002	.002	.002	.002	.002	.002	.002	.003	.003	.003	.003

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* "Smithsonian Meteorological Tables," p. 58.

TABLE 102.

REDUCTION OF BAROMETER TO STANDARD GRAVITY.*

Reduction to Latitude 45°. — Metric Scale.

N. B. — From latitude 0° to 44° the correction is to be subtracted.
From latitude 90° to 46° the correction is to be added.

Latitude.		Height of the barometer in millimetres.											
		520	560	600	620	640	660	680	700	720	740	760	780
		mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
0°	**90°**	1.38	1.49	1.60	1.65	1.70	1.76	1.81	1.86	1.92	1.97	2.02	2.08
5	**85**	1.36	1.47	1.57	1.63	1.68	1.73	1.81	1.84	1.89	1.94	1.99	2.04
6	84	1.35	1.46	1.56	1.61	1.67	1.72	1.78	1.82	1.87	1.93	1.98	2.03
7	83	1.34	1.45	1.55	1.60	1.65	1.70	1.77	1.81	1.86	1.91	1.96	2.01
8	82	1.33	1.43	1.54	1.59	1.64	1.69	1.76	1.79	1.84	1.89	1.94	2.00
9	81	1.32	1.42	1.52	1.57	1.62	1.67	1.74	1.77	1.82	1.87	1.92	1.97
10	**80**	1.30	1.40	1.50	1.55	1.60	1.65	1.70	1.75	1.80	1.85	1.90	1.95
11	79	1.28	1.38	1.48	1.53	1.58	1.63	1.68	1.73	1.78	1.83	1.88	1.93
12	78	1.26	1.36	1.46	1.51	1.56	1.60	1.65	1.70	1.75	1.80	1.85	1.90
13	77	1.24	1.34	1.44	1.48	1.53	1.58	1.63	1.67	1.72	1.77	1.82	1.87
14	76	1.22	1.32	1.41	1.46	1.50	1.55	1.60	1.65	1.69	1.74	1.79	1.83
15	**75**	1.20	1.29	1.38	1.43	1.48	1.52	1.57	1.61	1.66	1.71	1.75	1.80
16	74	1.17	1.26	1.35	1.40	1.44	1.49	1.54	1.58	1.63	1.67	1.72	1.76
17	73	1.15	1.24	1.32	1.37	1.41	1.45	1.50	1.54	1.59	1.63	1.68	1.72
18	72	1.12	1.21	1.29	1.34	1.38	1.42	1.46	1.51	1.55	1.59	1.64	1.68
19	71	1.09	1.17	1.26	1.30	1.34	1.38	1.43	1.47	1.51	1.55	1.59	1.64
20	**70**	1.06	1.14	1.22	1.26	1.31	1.35	1.39	1.43	1.47	1.51	1.55	1.59
21	69	1.03	1.11	1.19	1.23	1.27	1.31	1.35	1.38	1.42	1.46	1.50	1.54
22	68	1.00	1.07	1.15	1.19	1.23	1.26	1.30	1.34	1.38	1.42	1.46	1.49
23	67	0.96	1.04	1.11	1.15	1.18	1.22	1.26	1.29	1.33	1.37	1.41	1.44
24	66	.93	1.00	1.07	1.10	1.14	1.18	1.21	1.25	1.28	1.32	1.35	1.39
25	**65**	0.89	0.96	1.03	1.06	1.10	1.13	1.16	1.20	1.23	1.27	1.30	1.33
26	64	.85	.92	0.98	1.02	1.05	1.08	1.11	1.15	1.18	1.21	1.25	1.28
27	63	.81	.88	.94	0.97	1.00	1.03	1.06	1.10	1.13	1.16	1.19	1.22
28	62	.77	.83	.89	.92	0.95	0.98	1.01	1.04	1.07	1.10	1.13	1.16
29	61	.73	.79	.85	.87	.90	.93	0.96	0.99	1.02	1.04	1.07	1.10
30	**60**	0.69	0.75	0.80	0.83	0.85	0.88	0.91	0.94	0.96	0.98	1.01	1.04
31	59	.65	.70	.75	.77	.80	.82	.85	.87	.90	.92	0.95	0.97
32	58	.61	.65	.70	.72	.75	.77	.79	.82	.84	.86	.89	.91
33	57	.56	.61	.65	.67	.69	.71	.74	.76	.78	.80	.82	.84
34	56	.52	.56	.60	.62	.64	.66	.68	.70	.72	.74	.76	.78
35	**55**	0.47	0.51	0.55	0.56	0.58	0.60	0.62	0.64	0.66	0.67	0.69	0.71
36	54	.43	.46	.49	.51	.53	.54	.56	.58	.59	.61	.63	.64
37	53	.38	.41	.44	.45	.47	.48	.50	.51	.53	.54	.56	.57
38	52	.33	.36	.39	.40	.41	.43	.44	.45	.46	.48	.49	.50
39	51	.29	.31	.33	.34	.35	.37	.38	.39	.40	.41	.42	.43
40	**50**	0.24	0.26	0.28	0.29	0.30	0.31	0.31	0.32	0.33	0.34	0.35	0.36
41	49	.19	.21	.22	.23	.24	.24	.25	.26	.27	.27	.28	.29
42	48	.14	.16	.17	.17	.18	.18	.19	.19	.20	.21	.21	.22
43	47	.10	.10	.11	.12	.12	.12	.13	.13	.13	.14	.14	.14
44	46	.05	.05	.06	.06	.06	.06	.06	.07	.07	.07	.07	.07

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* "Smithsonian Meteorological Tables," p. 59.

CORRECTION OF THE BAROMETER FOR CAPILLARITY.*

1. METRIC MEASURE.

Diameter of tube in mm.	HEIGHT OF MENISCUS IN MILLIMETRES.							
	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8
	Correction to be added in millimetres.							
4	0.83	1.22	1.54	1.98	2.37	–	–	–
5	.47	0.65	0.86	1.19	1.45	1.80	–	–
6	.27	.41	.56	0.78	0.98	1.21	1.43	–
7	.18	.28	.40	.53	.67	0.82	0.97	1.13
8	–	.20	.29	.38	.46	.56	.65	0.77
9	–	.15	.21	.28	.33	.40	.46	.52
10	–	–	.15	.20	.25	.29	.33	.37
11	–	–	.10	.14	.18	.21	.24	.27
12	–	–	.07	.10	.13	.15	.18	.19
13	–	–	.04	.07	.10	.12	.13	.14

2. BRITISH MEASURE.

Diameter of tube in inches.	HEIGHT OF MENISCUS IN INCHES.							
	.01	.02	.03	.04	.05	.06	.07	.08
	Correction to be added in hundredths of an inch.							
.15	2.36	4.70	6.86	9.23	11.56	–	–	–
.20	1.10	2.20	3.28	4.54	5.94	7.85	–	–
.25	0.55	1.20	1.92	2.76	3.68	4.72	5.88	–
.30	.36	0.79	1.26	1.77	2.30	2.88	3.48	4.20
.35	–	.51	0.82	1.15	1.49	1.85	2.24	2.65
.40	–	.40	.61	0.81	1.02	1.22	1.42	1.62
.45	–	–	.32	.51	0.68	0.83	0.96	1.15
.50	–	–	.20	.35	.47	.56	.64	0.71
.55	–	–	.08	.20	.31	.40	.47	.52

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* The first table is from Kohlrausch (Experimental Physics), and is based on the experiments of Mendelejeff and Gutkowski (Jour. de Phys. Chem. Geo. Petersburg, 1877, or Wied. Beib. 1867). The second table has been calculated from the same data by conversion into inches and graphic interpolation.

A number of tables, mostly based on theoretical formulæ and the capillary constants of mercury in glass tubes in air and vacuum, were given in the fourth edition of Guyot's Tables, and may be there referred to. They are not repeated here, as the above is probably more accurate, and historical matter is excluded for convenience in the use of the book.

AERODYNAMICS.

The pressure on a plane surface normal to the wind is for ordinary wind velocities expressed by

$$P = kwav^2$$

where k is a constant depending on the units employed, w the mass of unit volume of the air, a the area of the surface and v the velocity of the wind.* Engineers generally use the table of values of P given by Smeaton in 1759. This table was calculated from the formula

$$P = .00492\,v^2$$

and gives the pressure in pounds per square foot when v is expressed in miles per hour. The corresponding formula when v is expressed in feet per second is

$$P = .00228\,v^2.$$

Later determinations do not agree well together, but give on the average somewhat lower values for the coefficient. The value of w depends, of course, on the temperature and the barometric pressure. Langley's experiments give $kw = .00166$ at ordinary barometric pressure and 10° C. temperature.

For planes inclined at an angle α less than 90° to the direction of the wind the pressure may be expressed as $P_\alpha = F_\alpha P_{90}$.

Table 104, founded on the experiments of Langley, gives the value of F_α for different values of α. The word *aspect*, in the headings, is used by him to define the position of the plane relative to the direction of motion. The numerical value of the aspect is the ratio of the linear dimension transverse to the direction of motion to the linear dimension, a vertical plane through which is parallel to the direction of motion.

TABLE 104. — Values of F_α in Equation $P_\alpha = F_\alpha P_{90}$.

Plane 30 in. × 4.8 in. Aspect 6 (nearly).		Plane 12 in. × 12 in. Aspect 1.		Plane 6 in. × 24 in. Aspect ¼.	
α	F_α	α	F_α	α	F_α
0°	0.00	0°	0.00	0°	0.00
5	0.28	5	0.15	5	0.07
10	0.44	10	0.30	10	0.17
15	0.55	15	0.44	15	0.29
20	0.62	20	0.57	20	0.43
25	0.66	25	0.69	25	0.58
30	0.69	30	0.78	30	0.71
35	0.72	35	0.84	–	–
40	0.74	40	0.88	–	–
45	0.76	45	0.91	–	–
50	0.78	50	–	–	–

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* The following pressures in pounds per square inch show roughly the influence of the shape and size of the resisting surface (Dines' results). The wind velocity was 20.9 miles per hour. The flat plates were ⅜ in. thick.

Square, sides 4 in.	1.51	Plate, 6 in. diam. 90° cone at back	1.49
Circle, same area	1.51	Same, cone in front	0.98
Rectangle, 16 in. by 1	1 70	" sharp 30° cone at back	1.54
Square, 12 in. sides	1.57	" cone in front	0.60
Circle, same area	1 55	5 in. Robinson cup on 8½ in. of ½ in. rod	1.68
Rectangle, 24 in. by 6	1.59	Same, with back to wind	0.73
Square, sides 16 in.	1.52	9 in. cup on 6½ in. of ⅝ in. rod	1.75
Plate, 6 in. diam. 4¾ thick	1.45	Same, with back to wind	0.60
Ditto, curved side to wind	0.92	2½ in. cup on 9¾ in. of ¼ in. rod	2.60
Sphere, 6 in. diam.	0.67	Same, with back to wind	1.04

AERODYNAMICS.

On the basis of the results given in Table 104 Langley states the following condition for the soaring of an aeroplane 76.2 centimetres long and 12.2 centimetres broad, weighing 500 grammes, — that is, a plane one square foot in area, weighing 1.1 pounds. It is supposed to soar in a horizontal direction, with aspect 6.

TABLE 105. – Data for the Soaring of Planes 76.2 × 12.2 cms. weighing 500 Grammes, Aspect 6.

Inclination to the horizontal α.	Soaring speed v.		Work expended per minute (activity).		Weight of planes of like form, capable of soaring at speed v with the expenditure of one horse power.	
	Metres per sec.	Feet per sec.	Kilogramme metres.	Foot pounds.	Kilogrammes.	Pounds.
2°	20.0	66	24	174	95.0	209
5	15.2	50	41	297	55.5	122
10	12.4	41	65	474	34.8	77
15	11.2	37	86	623	26.5	58
30	10.6	35	175	1268	13.0	29
45	11.2	37	336	2434	6.8	15

In general, if $\rho = \frac{\text{weight}}{\text{area}}$

Soaring speed $v = \sqrt{\frac{\rho}{k} \cdot \frac{1}{F_\alpha \cos \alpha}}$

Activity per unit of weight $= v \tan \alpha$

The following data for curved surfaces are due to Wellner (Zeits. für Luftschifffahrt, x., Oct. 1893).

Let the surface be so curved that its intersection with a vertical plane parallel to the line of motion is a parabola whose height is about $\frac{1}{12}$ the subtending chord, and let the surface be bounded by an elliptic outline symmetrical with the line of motion. Also, let the angle of inclination of the chord of the surface be α, and the angle between the direction of resultant air pressure and the normal to the direction of motion be β. Then $\beta < \alpha$, and the soaring speed is $v = \sqrt{\frac{\rho}{k} \cdot \frac{1}{F_\alpha \cos \beta}}$, while the activity per unit of weight $= v \tan \beta$.

The following series of values were obtained from experiments on moving trains and in the wind.

Angle of inclination $\alpha =$	$-3°$	$0°$	$+3°$	$6°$	$9°$	$12°$
Inclination factor $F_\alpha =$	0.20	0.50	0.75	0.90	1.00	1.05
$\tan \beta =$	0.01	0.02	0.03	0.04	0.10	0.17

Thus a curved surface shows finite soaring speeds when the angle of inclination α is zero or even slightly negative. Above $\alpha = 12°$ curved surfaces rapidly lose any advantage they may have for small inclinations.

TABLE 106.

FRICTION.

The following table of coefficients of friction f and its reciprocal $1/f$, together with the angle of friction or angle of repose ϕ, is quoted from Rankine's "Applied Mechanics." It was compiled by Rankine from the results of General Morin and other authorities, and is sufficient for all ordinary purposes.

Material.	f	$1/f$	ϕ
Wood on wood, dry	.25–.50	4.00–2.00	14.0–26.5
" " " soapy	.20	5.00	11.5
Metals on oak, dry	.50–.60	2.00–1.67	26.5–31.0
" " " wet	.24–.26	4.17–3.85	13.5–14.5
" " " soapy	.20	5.00	11.5
" " elm, dry	.20–.25	5.00–4.00	11.5–14.0
Hemp on oak, dry	.53	1.89	28.0
" " " wet	.33	3.00	18.5
Leather on oak	.27–.38	3.70–2.86	15.0–19.5
" " metals, dry	.56	1.79	29.5
" " " wet	.36	2.78	20.0
" " " greasy	.23	4.35	13.0
" " " oily	.15	6.67	8.5
Metals on metals, dry	.15–.20	6.67–5.00	8.5–11.5
" " " wet	.3	3.33	16.5
Smooth surfaces, occasionally greased	.07–.08	14.3–12.50	4.0–4.5
" " continually greased	.05	20.00	3.0
" " best results	.03–.036	33.3–27.6	1.75–2.0
Steel on agate, dry *	.20	5.00	11.5
" " " oiled *	.107	9.35	6.1
Iron on stone	.30–.70	3.33–1.43	16.7–35.0
Wood on stone	About .40	2.50	22.0
Masonry and brick work, dry	.60–.70	1.67–1.43	33.0–35.0
" " " " damp mortar	.74	1.35	36.5
" on dry clay	.51	1.96	27.0
" " moist clay	.33	3.00	18.25
Earth on earth	.25–1.00	4.00–1.00	14.0–45.0
" " " dry sand, clay, and mixed earth	.38–.75	2.63–1.33	21.0–37.0
" " " damp clay	1.00	1.00	45.0
" " " wet clay	.31	3.23	17.0
" " " shingle and gravel	.81–1.11	1.23–0.9	39.0–48.0

* Quoted from a paper by Jenkin and Ewing, "Phil. Trans. R. S." vol. 167. In this paper it is shown that in cases where "static friction" exceeds "kinetic friction" there is a gradual increase of the coefficient of friction as the speed is reduced towards zero.

TABLE 107.

VISCOSITY.

The coefficient of viscosity is the tangential force per unit area of one face of a plate of the fluid which is required to keep up unit distortion between the faces. Viscosity is thus measured in terms of the temporary rigidity which it gives to the fluid. Solids may be included in this definition when only that part of the rigidity which is due to varying distortion is considered. One of the most satisfactory methods of measuring the viscosity of fluids is by the observation of the rate of flow of the fluid through a capillary tube, the length of which is great in comparison with its diameter. Poiseuille * gave the following formula for calculating the viscosity coefficient in this case : $\mu = \frac{\pi h r^4 s}{8vl}$, where *h* is the pressure height, *r* the radius of the tube, *s* the density of the fluid, *v* the quantity flowing per unit time, and *l* the length of the capillary part of the tube. The liquid is supposed to flow from an upper to a lower reservoir joined by the tube, hence *h* and *l* are different. The product *hs* is the pressure under which the flow takes place. Hagenbach † pointed out that this formula is in error if the velocity of flow is sensible, and suggested a correction which was used in the calculation of his results. The amount to be subtracted from *h*, according to Hagenbach, is $\frac{v^2}{\sqrt{2} \cdot g}$, where *g* is the acceleration due to gravity. Gartenmeister ‡ points out an error in this to which his attention had been called by Finkener, and states that the quantity to be subtracted from *h* should be simply $\frac{v^2}{g}$; and this formula is used in the reduction of his observations. Gartenmeister's formula is the most accurate, but all of them nearly agree if the tube be long enough to make the rate of flow very small. None of the formulæ take into account irregularities in the distortion of the fluid near the ends of the tube, but this is probably negligible in all cases here quoted from, although it probably renders the results obtained by the "viscosimeter" commonly used for testing oils useless for our purpose.

The term "specific viscosity" is sometimes used in the headings of the tables; it means the ratio of the viscosity of the fluid under consideration to the viscosity of water at a specified temperature.

The friction of a fluid is proportional to the size of the rubbing surface, to $\frac{dv}{dx}$, where *v* is the velocity of motion in a direction perpendicular to the rubbing surface, and to a constant known as the viscosity.

Variation of Viscosity of Water, with Temperature. Dynes per sq. cm.

Temp. C.	Poiseville. 1846.	Sprung. 1876.	Slotte. 1883.	Thorpe-Rogers. 1894.§	Specific viscosity.	Temp. C.	Slotte. 1883.	Thorpe-Rogers. 1894.	Specific Viscosity.
0°	0.01716	0.01778	0.01808	0.01778	1.000	55°	0.00510	0.00506	.285
5	.01515	.01510	.01524	.01510	.849	60	.00472	.00468	.263
10	.01309	.01301	.01314	.01303	.733	65	.00438	.00436	.245
15	.01146	.01135	.01144	.01134	.638	70	.00408	.00406	.228
20	.01008	.01003	.01008	.01002	.564	75	.00382	.00380	.214
25	.00897	.00896	.00896	.00891	.501	80	.00358	.00356	.200
30	.00803	.00802	.00803	.00798	.449	85	.00337	.00335	.188
35	.00721	.00723	.00724	.00720	.405	90	.00318	.00316	.178
40	.00653	.00657	.00657	.00654	.368	95	.00301	.00299	.168
45	.00595	.00602	.00602	.00597	.336	100	.00285	.00283	.159
50	–	.00553	.00553	.00548	.308				

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* "Comptes rendus," vol. 15, 1842; "Mém. Serv. Étr." 1846.

† "Pogg. Ann." vol, 109, 1860.

‡ "Zeitschr. Phys. Chem." vol. 6, 1890.

§ Thorpe and Rogers, "Philos. Trans." 185A, 1894; "Proc. Roy. Soc." 55, 1894.

VISCOSITY.

TABLE 108.—Solution of Alcohol in Water.*

Coefficients of viscosity, in C. G. S. units, for solution of alcohol in water.

Temp. C.	Percentage by weight of alcohol in the mixture.								
	0	8.21	16.60	34.58	43.99	53.36	75.75	87.45	99.72
0°	0.0181	0.0287	0.0453	0.0732	0.0707	0.0632	0.0407	0.0294	0.0180
5	.0152	.0234	.0351	.0558	.0552	.0502	.0344	.0256	.0163
10	.0131	.0195	.0281	.0435	.0438	.0405	.0292	.0223	.0148
15	.0114	.0165	.0230	.0347	.0353	.0332	.0250	.0195	.0134
20	.0101	.0142	.0193	.0283	.0286	.0276	.0215	.0172	.0122
25	0.0090	0.0123	0.0163	0.0234	0.0241	0.0232	0.0187	0.0152	0.0110
30	.0081	.0108	.0141	.0196	.0204	.0198	.0163	.0135	.0100
35	.0073	.0096	.0122	.0167	.0174	.0171	.0144	.0120	.0092
40	.0067	.0086	.0108	.0143	.0150	.0149	.0127	.0107	.0084
45	.0061	.0077	.0095	.0125	.0131	.0130	.0113	.0097	.0077
50	0.0056	0.0070	0.0085	0.0109	0.0115	0.0115	0.0102	0.0088	0.0070
55	.0052	.0063	.0076	.0096	.0102	.0102	.0091	.0086	.0065
60	.0048	.0058	.0069	.0086	.0091	.0092	.0083	.0073	.0060

The following tables (152-153) contain the results of a number of experiments in the viscosity of mineral oils derived from petroleum residues and used for lubricating purposes.†

TABLE 109.—Mineral Oils.‡

Density.	Flashing point. ° C.	Burning point. ° C.	Sp. viscosity. Water at 20° C. = 1.		
			20° C.	50° C.	100° C.
.931	243	274	–	11.30	2.9
.921	216	246	–	7.31	2.5
.906	189	208	–	3.45	1.5
.921	163	190	–	27.80	2.8
.917	132	168	–	–	2.6
.904	170	207	8.65	2.65	1.7
.891	151	182	4.77	1.86	1.3
.878	108	148	2.94	1.48	–
.855	42	45	1.65	–	–
.905	165	202	–	3.10	1.5
.894	139	270	7.60	3.60	1.3
.866	90	224	2.50	1.50	–

TABLE 110.—Oils.

Oil.	Density.	Flashing point. ° C.	Burning point. ° C.	Viscosity at 19° C., water at 19° C. = 1.
Cylinder oil . .	.917	227	274	191
Machine oil . .	.914	213	260	102
Wagon oil . .	.914	148	182	80
" " . .	.911	157	187	70
Naphtha residue	.910	134	162	55
Oleo-naphtha .	.910	219	257	121
" " .	.904	201	242	66
" " .	.894	184	222	26
Oleonid . . .	.884	185	217	28
" best quality	.881	188	224	20
Olive oil . . .	.916	–	–	22
Whale oil . .	.879	–	–	9
" " . .	.875	–	–	8

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* This table was calculated from the table of fluidities given by Noack (Wied. Ann. vol. 27, p. 217), and shows a maximum for a solution containing about 40 per cent of alcohol. A similar result was obtained for solutions of acetic acid.

† Table 152 is from a paper by Engler in Dingler's "Poly. Jour." vol. 268, p. 76, and Table 153 is from a paper by Lamansky in the same journal, vol. 248, p. 29. The very mixed composition of these oils renders the viscosity a very uncertain quantity, neither the density nor the flashing point being a good guide to viscosity.

‡ The different groups in this table are from different residues.

TABLE 111.

VISCOSITY.

This table gives some miscellaneous data as to the viscosity of liquids, mostly referring to oils and paraffins. The viscosities are in C. G. S. units.

Liquid.		G. %	Coefficient of viscosity.	Temp. Cent. °	Authority.
Ammonia			0.0160	11.9	Poiseuille.
"			0.0149	14.5	"
Anisol			0.0111	20.0	Gartenmeister.
Glycerine			42.20	2.8	Schottner.
"			25.18	8.1	"
"			13.87	14.3	"
"			8.30	20.3	"
"			4.94	26.5	"
Glycerine and water		94.46	7.437	8.5	"
" "		80.31	1.021	8.5	"
" "		64.05	0.222	8.5	"
" "		49.79	0.092	8.5	"
Glycol			0.0219	0.0	Arrhenius.
Mercury *			0.0184	—20	Koch.
"			0.0170	0.0	"
"			0.0157	20.0	"
"			0.0122	100.0	"
"			0.0102	200.0	"
"			0.0093	300.0	"
Meta-cresol			0.1878	20.0	Gartenmeister.
Olive oil			0.9890	15.0	Brodmann.
Paraffins:	Decane		0.0077	22.3	Bartolli & Stracciati.
	Dodecane		0.0126	23.3	" "
	Heptane		0.0045	24.0	" "
	Hexadecane		0.0359	22.2	" "
	Hexane		0.0033	23.7	" "
	Nonane		0.0062	22.3	" "
	Octane		0.0053	22.2	" "
	Pentane		0.0026	21.0	" "
	Pentadecane		0.0281	22.0	" "
	Tetradecane		0.0213	21.9	" "
	Tridecane		0.0155	23.3	" "
	Undecane		0.0095	22.7	" "
Petroleum (Caucasian)			0.0190	17.5	Petroff.
Rape oil			25.3	0.0	O. E. Meyer.
" "			3.85	10.0	"
" "			1.63	20.0	"
" "			0.96	30.0	"

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* Calculated from the formula $\mu = .017 - .000066t + 00000021t^2 - .000000000025t^3$ (vide Koch, Wied. Ann. vol. 14. p. 1).

TABLE 112.

VISCOSITY.

This table gives the viscosity of a number of liquids together with their temperature variation. The headings are temperatures in Centigrade degrees, and the numbers under them the coefficients of viscosity in C. G. S. units.*

Liquid.	Temperature Centigrade.								Reference.
	0°	10°	20°	30°	40°	50°	70°	90°	
Acetates: Methyl	–	.0046	.0041	.0036	.0032	.0030	–	–	1
Ethyl	–	.0051	.0044	.0040	.0035	.0032	–	–	1
Propyl	–	.0066	.0059	.0052	.0044	.0039	–	–	1
Allyl	–	.0068	.0061	.0054	.0049	.0044	–	–	1
Amyl	–	.0106	.0089	.0077	.0065	.0058	–	–	1
Acids: Formic		.02262	.01804	.01465	.01224	.01025	–	–	2
Acetic	–	.0150	.0126	.0109	.0094	.0082	–	–	1
Propionic	–	.0125	.0107	.0092	.0081	.0073	–	–	3
"	–	.0139	.0118	.0101	.0091	.0080	–	–	1
Butyric	–	.0196	.0163	.0136	.0118	.0102	–	–	2
Valeric	–	.0271	.0220	.0183	.0155	.0127	–	–	3
Salicylic	–	.0320	.0271	.0222	.0181	.0150	–	–	3
Alcohol: Methyl	.00813	.00686	.00591	.00515	.00450	.00396	–	–	4
Ethyl	.01770	.01449	.01192	.00990	.00828	.00698	.00504	–	4
Propyl	.03882	.02917	.02255	.01778	.01403	.01128	.00757	.00526	4
Butyric	.05185	.03872	.02947	.02266	.01780	.01409	.00926	.00633	4
Allyl	.02144	.01703	.01361	.01165	.00911	.00760	.00548	.00407	4
Isopropyl	.04564	.03245	.02369	.01755	.01329	.01026	.00642	–	4
Isobutyl	.08038	.05547	.03906	.02863	.02121	.01609	.00973	.00633	4
Amyl (op.-inac.)	.08532	.06000	.04341	.03206	.02414	.01849	.01147	.00758	4
Aldehyde	.00267	.00244	.00222	–	–	–	–	–	3
Aniline	–	–	.0440	.0319	.0241	.0189	–	–	5
Benzole	.00902	.00759	.00649	.00562	.00492	.00437	.00351	–	4
Bromides: Ethyl	.00478	.00432	.00392	.00357	–	–	–	–	4
Propyl	.00645	.00575	.00517	.00467	.00425	.00388	.00328	–	4
Allyl	.00619	.00552	.00496	.00449	.00410	.00374	.00316	–	4
Ethylene	.02435	.02035	.01716	.01470	.01280	.01124	.00895	.00733	4
Carbon bisulphide	.00429	.00396	.00367	.00342	.00319	–	–	–	4
Carbon dioxide (liq.)	.00099	.00085	.00071	–	–	–	–	–	6
Chlorides: Propyl	.00436	.00390	.00352	.00319	.00291	–	–	–	4
Allyl	.00402	.00358	.00322	.00292	–	–	–	–	4
Ethylene	.01128	.00961	.00833	.00730	.00646	.00576	.00470	–	4
Chloroform	.00700	.00626	.00564	.00511	.00466	.00390	–	–	4
Ether	–	.0026	.0023	.0021	–	–	–	–	1
Ethylbenzole	.00874	.00758	.00666	.00592	.00529	.00477	.00394	.00330	4
Ethylsulphide	.00559	.00496	.00444	.00401	.00363	.00331	.00279	.00237	4
Iodides: Methyl	.00594	.00536	.00487	.00446	.00409	–	–	–	
Ethyl	.00719	.00645	.00583	.00530	.00484	.00444	.00378	–	
Propyl	.00938	.00827	.00737	.00662	.00598	.00544	.00456	.00387	4
Allyl	.00930	.00819	.00726	.00652	.00588	.00534	.00448	.00381	4
Metaxylol	.00802	.00698	.00615	.00547	.00491	.00444	.00369	.00313	4
Nitrobenzene	–	–	.0203	.0170	.0144	.0124	–	–	1
Paraffines: Pentane	.00283	.00256	.00232	.00212	–	–	–	–	4
Hexane	.00396	.00355	.00320	.00290	.00264	.00241	.00221	–	4
Heptane	.00519	.00460	.00410	.00369	.00334	.00303	.00253	.00214	4
Octane	.00703	.00612	.00538	.00478	.00428	.00386	.00318	.00266	4
Isopentane	.00273	.00246	.00223	.00204	–	–	–	–	4
Isohexane	.00371	.00332	.00300	.00272	.00247	.00226	–	–	4
Isoheptane	.00477	.00423	.00379	.00342	.00309	.00282	.00235	.00200	4
Propyl aldehyde	–	.0047	.0041	.0036	.0033	–	–	–	1
Toluene	.00768	.00668	.00586	.00520	.00466	.00420	.00348	.00292	4

1 Pribram-Handl, Wien. Ber. 78, 1878, 80, 1879, 84, 1881.
2 Gartenmeister, Zeitschr. Phys. Chem. 6, 1890.
3 Rellstab, Diss. Bonn, 1868.
4 Thorpe-Roger, Philos. Trans. 185 A, 1894, 189 A, 1897; Proc. Roy. Soc. 55, 1894, 60, 1896; Jour. Chem. Soc. 71, 1897; Chem. News, 75, 1897.
5 Wijkander, Wied. Beibl. 3, 1879.
6 Warburg-Babo, Wied. Ann. 17, 1882.

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* Calculated from the specific viscosities given in Landolt & Börnstein's Phys. Chem. Tab.

For inorganic acids, see Solutions.

TABLE 113.

VISCOSITY OF SOLUTIONS.

This table is intended to show the effect of change of concentration and change of temperature on the viscosity of solutions of salts in water. The specific viscosity × 100 is given for two or more densities and for several temperatures in the case of each solution. μ stands for specific viscosity, and *t* for temperature Centigrade.

Salt.	Percentage by weight of salt in solution.	Density.	μ	*t*	μ	*t*	μ	*t*	μ	*t*	Authority.
$BaCl_2$	7.60	–	77.9	10	44.0	30	35.2	50	–	–	Sprung.
"	15.40	–	86.4	"	56.0	"	39.6	"	–	–	"
"	24.34	–	100.7	"	66.2	"	47.7	"	–	–	"
$Ba(NO_3)_2$	2.98	1.027	62.0	15	51.1	25	42.4	35	34.8	45	Wagner.
"	5.24	1.051	68.1	"	54.2	"	44.1	"	36.9	"	"
$CaCl_2$	15.17	–	110.9	10	71.3	30	50.3	50	–	–	Sprung.
"	31.60	–	272.5	"	177.0	"	124.0	"	–	–	"
"	39.75	–	670.0	"	379.0	"	245.5	"	–	–	"
"	44.09	–	–	–	593.1	"	363.2	"	–	–	"
$Ca(NO_3)_2$	17.55	1.171	93.8	15	74.6	25	60.0	35	49.9	45	Wagner.
"	30.10	1.274	144.1	"	112.7	"	90.7	"	75.1	"	"
"	40.13	1.386	242.6	"	217.1	"	156.5	"	128.1	"	"
$CdCl_2$	11.09	1.109	77.5	15	60.5	25	49.1	35	40.7	45	"
"	16.30	1.181	88.9	"	70.5	"	57.5	"	47.2	"	"
"	24.79	1.320	104.0	"	80.4	"	64.6	"	53.6	"	"
$Cd(NO_3)_2$	7.81	1.074	61.9	15	50.1	25	41.1	35	34.0	45	"
"	15.71	1.159	71.8	"	58.7	"	48.8	"	41.3	"	"
"	22.36	1.241	85.1	"	69.0	"	57.3	"	47.5	"	"
$CdSO_4$	7.14	1.068	78.9	15	61.8	25	49.9	35	41.3	45	"
"	14.66	1.159	96.2	"	72.4	"	58.1	"	48.8	"	"
"	22.01	1.268	120.8	"	91.8	"	73.5	"	60.1	"	"
$CoCl_2$	7.97	1.081	83.0	15	65.1	25	53.6	35	44.9	45	"
"	14.86	1.161	111.6	"	85.1	"	73.7	"	58.8	"	"
"	22.27	1.264	161.6	"	126.6	"	101.6	"	85.6	"	"
$Co(NO_3)_2$	8.28	1.073	74.7	15	57.9	25	48.7	35	39.8	45	"
"	15.96	1.144	87.0	"	69.2	"	55.4	"	44.9	"	"
"	24.53	1.229	110.4	"	88.0	"	71.5	"	59.1	"	"
$CoSO_4$	7.24	1.086	86.7	15	68.7	25	55.0	35	45.1	45	"
"	14.16	1.159	117.8	"	95.5	"	76.0	"	61.7	"	"
"	21.17	1.240	193.6	"	146.2	"	113.0	"	89.9	"	"
$CuCl_2$	12.01	1.104	87.2	15	67.8	25	55.1	35	45.6	45	"
"	21.35	1.215	121.5	"	95.8	"	77.0	"	63.2	"	"
"	33.03	1.331	178.4	"	137.2	"	107.6	"	87.1	"	"
$Cu(NO_3)_2$	18.99	1.177	97.3	15	76.0	25	61.5	35	51.3	45	"
"	26.68	1.264	126.2	"	98.8	"	80.9	"	68.6	"	"
"	46.71	1.536	382.9	"	283.8	"	215.3	"	172.2	"	"
$CuSO_4$	6.79	1.055	79.6	15	61.8	25	49.8	35	41.4	45	"
"	12.57	1.115	98.2	"	74.0	"	59.7	"	52.0	"	"
"	17.49	1.163	124.5	"	96.8	"	75.9	"	61.8	"	"
HCl	8.14	1.037	71.0	15	57.9	25	48.3	35	40.1	45	"
"	16.12	1.084	80.0	"	66.5	"	56.4	"	48.1	"	"
"	23.04	1.114	91.8	"	79.9	"	65.9	"	56.4	"	"
$HgCl_2$	0.23	1.023	–	–	58.5	20	46.8	30	38.3	40	"
"	3.55	1.033	76.75	10	59.2	"	46.6	"	38.3	"	"

VISCOSITY OF SOLUTIONS.

Salt.	Percentage by weight of salt in solution.	Density.	μ	t	μ	t	μ	t	μ	t	Authority.
HNO_3	8.37	1.067	66.4	15	54.8	25	45.4	35	37.6	45	Wagner.
“	12.20	1.116	69.5	“	57.3	“	47.9	“	40.7	“	“
“	28.31	1.178	80.3	“	65.5	“	54.9	“	46.2	“	“
H_2SO_4	7.87	1.065	77.8	15	61.0	25	50.0	35	41.7	45	“
“	15.50	1.130	95.1	“	75.0	“	60.5	“	49.8	“	“
“	23.43	1.200	122.7	“	95.5	“	77.5	“	64.3	“	“
KCl	10.23	–	70.0	10	46.1	30	33.1	50	–	–	Sprung.
“	22.21	–	70.0	“	48.6	“	36.4	“	–	–	“
KBr	14.02	–	67.6	10	44.8	30	32.1	50	–	–	“
“	23.16	–	66.2	“	44.7	“	33.2	“	–	–	“
“	34.64	–	66.6	“	47.0	“	35.7	“	–	–	“
KI	8.42	–	69.5	10	44.0	30	31.3	50	–	–	“
“	17.01	–	65.3	“	42.9	“	31.4	“	–	–	“
“	33.03	–	61.8	“	42.9	“	32.4	“	–	–	“
“	45.98	–	63.0	“	45.2	“	35.3	“	–	–	“
“	54.00	–	68.8	“	48.5	“	37.6	“	–	–	“
$KClO_3$	3.51	–	71.7	10	44.7	30	31.5	50	–	–	“
“	5.69	–	–	“	45.0	“	31.4	“	–	–	“
KNO_3	6.32	–	70.8	10	44.6	30	31.8	50	–	–	“
“	12.19	–	68.7	“	44.8	“	32.3	“	–	–	“
“	17.60	–	68.8	“	46.0	“	33.4	“	–	–	“
K_2SO_4	5.17	–	77.4	10	48.6	30	34.3	50	–	–	“
“	9.77	–	81.0	“	52.0	“	36.9	“	–	–	“
K_2CrO_4	11.93	–	75.8	10	62.5	30	41.0	40	–	–	“
“	19.61	–	85.3	“	68.7	“	47.9	“	–	–	“
“	24.26	1.233	97.8	“	74.5	“	54.5	“	–	–	Slotte.
“	32.78	–	109.5	“	88.9	“	62.6	“	–	–	Sprung.
$K_2Cr_2O_7$	4.71	1.032	72.6	10	55.9	20	45.3	30	37.5	40	Slotte.
“	6.97	1.049	73.1	“	56.4	“	45.5	“	37.7	“	“
LiCl	7.76	–	96.1	10	59.7	30	41.2	50	–	–	Sprung.
“	13.91	–	121.3	“	75.9	“	52.6	“	–	–	“
“	26.93	–	229.4	“	142.1	“	98.0	“	–	–	“
$Mg(NO_3)_2$	18.62	1.102	99.8	15	81.3	25	66.5	35	56.2	45	Wagner.
“	34.19	1.200	213.3	“	164.4	“	132.4	“	109.9	“	“
“	39.77	1.430	317.0	“	250.0	“	191.4	“	158.1	“	“
$MgSO_4$	4.98	–	96.2	10	59.0	30	40.9	50	–	–	Sprung.
“	9.50	–	130.9	“	77.7	“	53.0	“	–		“
“	19.32	–	302.2	“	166.4	“	106.0	“	–	–	“
$MgCrO_4$	12.31	1.089	111.3	10	84.8	20	67.4	30	55.0	40	Slotte.
“	21.86	1.164	167.1	“	125.3	“	99.0	“	79.4	“	“
“	27.71	1.217	232.2	“	172.6	“	133.9	“	106.6	“	“
$MnCl_2$	8.01	1.096	92.8	15	71.1	25	57.5	35	48.1	45	Wagner.
“	15.65	1.196	130.9	“	104.2	“	84.0	“	68.7	“	“
“	30.33	1.337	256.3	“	193.2	“	155.0	“	123.7	“	“
“	40.13	1.453	537.3	“	393.4	“	300.4	“	246.5	“	“

VISCOSITY OF SOLUTIONS.

Salt.	Percentage by weight of salt in solution.	Density.	μ	t	μ	t	μ	t	μ	t	Authority.
$Mn(NO_3)_2$	18.31	1.148	96.0	15	76.4	25	64.5	35	55.6	45	Wagner.
"	29.60	1.323	167.5	"	126.0	"	104.6	"	88.6	"	"
"	49.31	1.506	396.8	"	301.1	"	221.0	"	188.8	"	"
$MnSO_4$	11.45	1.147	129.4	15	98.6	25	78.3	35	63.4	45	"
"	18.80	1.251	228.6	"	172.2	"	137.1	"	107.4	"	"
"	22.08	1.306	661.8	"	474.3	"	347.9	"	266.8	"	"
$NaCl$	7.95	–	82.4	10	52.0	30	31.8	50	–	–	Sprung.
"	14.31	–	94.8	"	60.1	"	36.9	"	–	–	"
"	23.22	–	128.3	"	79.4	"	47.4	"	–	–	"
$NaBr$	9.77	–	75.6	10	48.7	30	34.4	50	–	–	"
"	18.58	–	82.6	"	53.5	"	38.2	"	–	–	"
"	27.27	–	95.9	"	61.7	"	43.8	"	–	–	"
NaI	8.83	–	73.1	10	46.0	30	32.4	50	–	–	"
"	17.15	–	73.8	"	47.4	"	33.7	"	–	–	"
"	35.69	–	86.0	"	55.7	"	40.6	"	–	–	"
"	55.47	–	157.2	"	96.4	"	66.9	"	–	–	"
$NaClO_3$	11.50	–	78.7	10	50.0	30	35.3	50	–	–	"
"	20.59	–	88.9	"	56.8	"	40.4	"	–	–	"
"	33.54	–	121.0	"	75.7	"	53.0	"	–	–	"
$NaNO_3$	7.25	–	75.6	10	47.9	30	33.8	50	–	–	"
"	12.35	–	81.2	"	51.0	"	36.1	"	–		"
"	18.20	–	87.0	"	55.9	"	39.3	"	–	–	"
"	31.55	–	121.2	"	76.2	"	53.4	"	–	–	"
Na_2SO_4	4.98	–	96.2	10	59.0	30	40.9	50	–	–	"
"	9.50	–	130.9	"	77.7	"	53.0	"	–	–	"
"	14.03	–	187.9	"	107.4	"	71.1	"	–	–	"
"	19.32	–	302.2	"	166.4	"	106.0	"	–	–	"
Na_2CrO_4	5.76	1.058	85.8	10	66.6	20	53.4	30	43.8	40	Slotte.
"	10.62	1.112	103.3	"	79.3	"	63.5	"	52.3	"	"
"	14.81	1.164	127.5	"	97.1	"	77.3	"	63.0	"	"
NH_4Cl	3.67	–	71.5	10	45.0	30	31.9	50	–	–	Sprung.
"	8.67	–	69.1	"	45.3	"	32.6	"	–	–	"
"	15.68	–	67.3	"	46.2	"	34.0	"	–		"
"	23.37	–	67.4	"	47.7	"	36.1	"	–	–	"
NH_4Br	15.97	–	65.2	10	43.2	30	31.5	50	–	–	"
"	25.33	–	62.6	"	43.3	"	32.2	"	–	–	"
"	36.88	–	62.4	"	44.6	"	34.3	"	–	–	"
NH_4NO_3	5.97	–	69.6	10	44.3	30	31.6	50	–	–	"
"	12.19	–	66.8	"	44.3	"	31.9	"	–	–	"
"	27.08	–	67.0	"	47.7	"	34.9	"	–	–	"
"	37.22	–	71.7	"	51.2	"	38.8	"	–	–	"
"	49.83	–	81.1	"	63.3	"	48.9	"	–	–	"
$(NH_4)_2SO_4$	8.10	–	107.9	10	52.3	30	37.0	50	–	–	"
"	15.94	–	120.2	"	60.4	"	43.2	"	–	–	"
"	25.51	–	148.4	"	74.8	"	54.1	"	–	–	"

VISCOSITY OF SOLUTIONS.

Salt.	Percentage by weight of salt in solution.	Density.	μ	t	μ	t	μ	t	μ	t	Authority.
$(NH_4)_2CrO_4$	10.52	1.063	79.3	10	62.4	20	–	–	42.4	40	Slotte.
"	19.75	1.120	88.2	"	70.0	"	57.8	30	48.4	–	"
"	28.04	1.173	101.1	"	80.7	"	60.8	"	56.4	–	"
$(NH_4)_2Cr_2O_7$	6.85	1.039	72.5	10	56.3	20	45.8	30	38.0	40	"
"	13.00	1.078	72.6	"	57.2	"	46.8	"	39.1	"	"
"	19.93	1.126	77.6	"	58.8	"	48.7	"	40.9	"	"
$NiCl_2$	11.45	1.109	90.4	15	70.0	25	57.5	35	48.2	45	Wagner.
"	22.69	1.226	140.2	"	109.7	"	87.8	"	72.7	"	"
"	30.40	1.337	229.5	"	171.8	"	139.2	"	111.9	"	"
$Ni(NO_3)_2$	16.49	1.136	90.7	15	70.1	25	57.4	35	48.9	45	"
"	30.01	1.278	135.6	"	105.9	"	85.5	"	70.7	"	"
"	40.95	1.388	222.6	"	169.7	"	128.2	"	152.4	"	"
$NiSO_4$	10.62	1.092	94.6	15	73.5	25	60.1	35	49.8	45	"
"	18.19	1.198	154.9	"	119.9	"	99.5	"	75.7	"	"
"	25.35	1.314	298.5	"	224.9	"	173.0	"	152.4	"	"
$Pb(NO_3)_2$	17.93	1.179	74.0	15	59.1	25	48.5	35	40.3	45	"
"	32.22	1.362	91.8	"	72.5	"	59.6	"	50.6	"	"
$Sr(NO_3)_2$	10.29	1.088	69.3	15	56.0	25	45.9	35	39.1	45	"
"	21.19	1.124	87.3	"	69.2	"	57.8	"	48.1	"	"
"	32.61	1.307	116.9	"	93.3	"	76.7	"	62.3	"	"
$ZnCl_2$	15.33	1.146	93.6	15	72.7	25	57.8	35	48.2	45	"
"	23.49	1.229	111.5	"	86.6	"	69.8	"	57.5	"	"
"	33.78	1.343	151.7	"	117.9	"	90.0	"	72.6	"	"
$Zn(NO_3)_2$	15.95	1.115	80.7	15	64.3	25	52.6	35	43.8	45	"
"	30.23	1.229	104.7	"	85.7	"	69.5	"	57.7	"	"
"	44.50	1.437	167.9	"	130.6	"	105.4	"	87.9	"	"
$ZnSO_4$	7.12	1.106	97.1	15	79.3	25	62.7	35	51.5	45	"
"	16.64	1.195	156.0	"	118.6	"	94.2	"	73.5	"	"
"	23.09	1.281	232.8	"	177.4	"	135.2	"	108.1	"	"

Table 114.

SPECIFIC VISCOSITY.*

Dissolved salt.	Normal solution.		½ normal.		¼ normal.		⅛ normal.		Authority.
	Density.	Specific viscosity.	Density.	Specific viscosity.	Density.	Specific viscosity.	Density.	Specific viscosity.	
Acids: Cl_2O_3 . .	1.0562	1.012	1.0283	1.003	1.0143	1.000	1.0074	0.999	Reyher.
HCl . . .	1.0177	1.067	1.0092	1.034	1.0045	1.017	1.0025	1.009	"
$HClO_3$ . .	1.0485	1.052	1.0244	1.025	1.0126	1.014	1.0064	1.006	"
HNO_3 . .	1.0332	1.027	1.0168	1.011	1.0086	1.005	1.0044	1.003	"
H_2SO_4 . .	1.0303	1.090	1.0154	1.043	1.0074	1.022	1.0035	1.008	Wagner.
Aluminium sulphate	1.0550	1.406	1.0278	1.178	1.0138	1.082	1.0068	1.038	"
Barium chloride . .	1.0884	1.123	1.0441	1.057	1.0226	1.026	1.0114	1.013	"
" nitrate . .	–	–	1.0518	1.044	1.0259	1.021	1.0130	1.008	"
Calcium chloride .	1.0446	1.156	1.0218	1.076	1.0105	1.036	1.0050	1.017	"
" nitrate . .	1.0596	1.117	1.0300	1.053	1.0151	1.022	1.0076	1.008	"
Cadmium chloride .	1.0779	1.134	1.0394	1.063	1.0197	1.031	1.0098	1.020	"
" nitrate .	1.0954	1.165	1.0479	1.074	1.0249	1.038	1.0119	1.018	"
" sulphate.	1.0973	1.348	1.0487	1.157	1.0244	1.078	1.0120	1.033	"
Cobalt chloride . .	1.0571	1.204	1.0286	1.097	1.0144	1.048	1.0058	1.023	"
" nitrate . .	1.0728	1.166	1.0369	1.075	1.0184	1.032	1.0094	1.018	"
" sulphate . .	1.0750	2.354	1.0383	1.160	1.0193	1.077	1.0110	1.040	"
Copper chloride . .	1.0624	1.205	1.0313	1.098	1.0158	1.047	1.0077	1.027	"
" nitrate . .	1.0755	1.179	1.0372	1.080	1.0185	1.040	1.0092	1.018	"
" sulphate .	1.0790	1.358	1.0402	1.160	1.0205	1.080	1.0103	1.038	"
Lead nitrate . . .	1.1380	1.101	0.0699	1.042	1.0351	1.017	1.0175	1.007	"
Lithium chloride .	1.0243	1.142	1.0129	1.066	1.0062	1.031	1.0030	1.012	"
" sulphate .	1.0453	1.290	1.0234	1.137	1.0115	1.065	1.0057	1.032	"
Magnesium chloride	1.1375	1.201	1.0188	1.094	1.0091	1.044	1.0043	1.021	"
" nitrate .	1.0512	1.171	1.0259	1.082	1.0130	1.040	1.0066	1.020	"
" sulphate	1.0584	1.367	1.0297	1.164	1.0152	1.078	1.0076	1.032	"
Manganese chloride	1.0513	1.209	1.0259	1.098	1.0125	1.048	1.0063	1.023	"
" nitrate .	1.0690	1.183	1.0349	1.087	1.0174	1.043	1.0093	1.023	"
" sulphate	1.0728	1.364	1.0365	1.169	1.0179	1.076	1.0087	1.037	"
Nickel chloride . .	1.0591	1.205	1.0308	1.097	1.0144	1.044	1.0067	1.021	"
" nitrate. . .	1.0755	1.180	1.0381	1.084	1.0192	1.042	1.0096	1.019	"
" sulphate . .	1.0773	1.361	1.0391	1.161	1.0198	1.075	1.0017	1.032	"
Potassium chloride .	1.0466	0.987	1.0235	0.987	1.0117	0.990	1.0059	0.993	"
" chromate	1.0935	1.113	1.0475	1.053	1.0241	1.022	1.0121	1.012	"
" nitrate .	1.0605	0.975	1.0305	0.982	1.0161	0.987	1.0075	0.992	"
" sulphate	1.0664	1.105	1.0338	1.049	1.0170	1.021	1.0084	1.008	"
Sodium chloride. .	1.0401	1.097	1.0208	1.047	1.0107	1.024	1.0056	1.013	Reyher.
" bromide. .	1.0786	1.064	1.0396	1.030	1.0190	1.015	1.0100	1.008	"
" chlorate .	1.0710	1.090	1.0359	1.042	1.0180	1.022	1.0092	1.012	"
" nitrate . .	1.0554	1.065	1.0281	1.026	1.0141	1.012	1.0071	1.007	"
Silver nitrate . . .	1.1386	1.058	1.0692	1.020	1.0348	1.006	1.0173	1.000	Wagner.
Strontium chloride .	1.0676	1.141	1.0336	1.067	1.0171	1.034	1.0084	1.014	"
" nitrate .	1.0822	1.115	1.0419	1.049	1.0208	1.024	1.0104	1.011	"
Zinc chloride . . .	1.0590	1.189	1.0302	1.096	1.0152	1.053	1.0077	1.024	"
" nitrate . . .	1.0758	1.164	1.0404	1.086	1.0191	1.039	1.0096	1.019	"
" sulphate. . .	1.0792	1.367	1.0402	1.173	1.0198	1.082	1.0094	1.036	"

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* In the case of solutions of salts it has been found (*vide* Arrhenius, Zeits. für Phys. Chem. vol. 1, p. 285) that the specific viscosity can, in many cases, be nearly expressed by the equation $\mu = \mu_1^n$, where μ_1 is the specific viscosity for a normal solution referred to the solvent at the same temperature, and n the number of gramme molecules in the solution under consideration. The same rule may of course be applied to solutions stated in percentages instead of gramme molecules. The table here given has been compiled from the results of Reyher (Zeits. für Phys. Chem. vol. 2, p. 749) and of Wagner (Zeits. für Phys. Chem. vol. 5, p. 31) and illustrates this rule. The numbers are all for 25° C.

TABLE 115.

VISCOSITY OF GASES AND VAPORS.

The values of μ given in the table are 10^6 times the coefficients of viscosity in C. G. S. units.

Substance.	Temp. ° C.	μ.	Reference.	Substance.	Temp. ° C.	μ.	Reference.
Acetone	18.0	78.	1	Chloroform	0.0	95.9	1
Air	-21.4	163.9	2	"	17.4	102.9	"
"	0.0	173.3	"	"	61.2	189.0	3
"	15.0	180.7	"	Ether	0.0	68.9	1
"	99.1	220.3	"	"	16.1	73.2	"
"	182.4	255.9	"	"	36.5	79.3	"
"	302.0	299.3	"	Ethyl iodide	72.3	216.0	3
Alcohol: Methyl	66.8	135.	3	Helium	0.0	189.1	5
" Ethyl	78.4	142.	"	"	15.3	196.9	"
" Propyl, norm.	97.4	142.	"	"	66.6	234.8	"
" Isopropyl	82.8	162.	"	"	184.6	269.9	"
" Butyl, norm.	116.9	143.	"	Hydrogen	-20.6	81.9	2
" Isobutyl	108.4	144.	"	"	15.0	88.9	"
" Tert. butyl	82.9	160.	"	"	99.2	105.9	"
Ammonia	0.0	96.	4	"	182.4	121.5	"
"	20.0	108.	"	"	302.0	139.2	"
Argon	0.0	210.4	5	Mercury	270.0	489.*	8
"	14.7	220.8	"	"	300.0	532.*	"
"	17.9	224.1	"	"	330.0	582.*	"
"	99.7	273.3	"	"	360.0	627.*	"
"	183.7	322.1	"	"	390.0	671.*	"
Benzole	19.0	79.	6	Methane	20.0	120.1	4
"	100.0	118.	"	Methyl iodide	44.0	232.	3
Carbon bisulphide	16.9	92.4	1	" chloride	15.0	105.2	2
" dioxide	-20.7	129.4	2	" "	302.0	213.9	"
" "	15.0	145.7	"	Nitrogen	-21.5	156.3	7
" "	99.1	186.1	"	"	10.9	170.7	"
" "	182.4	222.1	"	"	53.5	189.4	"
" "	302.0	268.2	"	Oxygen	15.4	195.7	"
" monoxide	0.0	163.0	4	"	53.5	215.9	"
" "	20.0	184.0	"	Water vapor	0.0	90.4	1
Chlorine	0.0	128.7	"	" "	16.7	96.7	"
"	20.0	147.0	"	" "	100.0	132.0	9

1 Puluj, Wien. Ber. 69, (2), 1874.
2 Breitenbach, Ann. Phys. 5, 1901.
3 Steudel, Wied. Ann. 16, 1882.
4 Graham, Philos. Trans. Lond. 1846, III.
5 Schultze, Ann. Phys. (4), 5, 6, 1901.
6 Schumann, Wied. Ann. 23, 1884.
7 Obermayer, Wien. Ber. 71, (2a), 1875.
8 Koch, Wied. Ann. 14, 1881, 19, 1883.
9 Meyer-Schumann, Wied. Ann. 13, 1881.

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* The values here given were calculated from Koch's table (Wied. Ann. vol. 19, p. 869) by the formula $\mu = 489\,[1 + 746\,(t—270)]$.

Table 116.

COEFFICIENT OF VISCOSITY OF GASES.

Temperature Coefficients.

If μ_t = the viscosity at t° C., μ_0 = the vicosity at 0°, α = the coefficient of expansion, β, γ, and n = coefficients independent of t, then

(I) $\mu_t = \mu_0(1+\alpha t)^n$. (Meyer, Obermayer, Puluj, Breitenbach.)

(II) $= \mu_0(1+\beta t)$. (Meyer, Obermayer.)

(III) $= \mu_0(1+\alpha t)^{\frac{1}{2}}(1+\gamma t)^2$. (Schumann.)

(IV) $= \mu_0 \dfrac{1+\dfrac{C}{273}}{1+\dfrac{C}{T}}\sqrt{1+\dfrac{t}{273}}$. (Sutherland.)

Gas.	$\mu_0 10^7$.	α.	Constants.	Range ° C.	Reference.
Air . . .	–	0.003665	$n=0.77$	0–100	1
“ . . .	1733.1	.003665	$C=119.4$		2
“ . . .	1811.	–	$n=0.7675$	15.0–99.7	3
“ . . .	2208.	–	$n=0.7544$	99.7–182.9	“
“ . . .	–	–	$n=0.754$; $C=111.3$	–	4
Argon . . .	–	–	$n=0.815$; $C=150.2$	15–100	4
“ . . .	2208.	–	$n=0.8227$; $C=169.9$	14.7–99.7	3
“ . . .	2733.	–	$n=0.8119$	99.7–183.7	3
Benzole . .	698.4	.004	$\gamma=0.00185$	18.7–100	5
Carbon dioxide .	1387.9	–	$C=239.7$	–	6
“ “ .	1497.2	.003701	$\gamma=0.000889$	12.8–100	5
“ “ .	1382.1	.003701	$\beta=0.00348$; $n=0.941$	–21.5–53.5	7
“ monoxide	1625.2	.003665	$\beta=0.00269$; $n=0.738$	17.5–53.5	“
Ether . . .	689.	.004158	$n=0.94$	0–36.5	8
Ethylene . .	961.3	–	$C=225.9$	–	6
“ . .	922.2	.003665	$\beta=0.00350$; $n=0.958$	–21.5–53.5	7
“ chloride	889.03	.003900	$\beta=0.00381$; $n=0.9772$	15.6–157.3	“
Helium . .	–	–	$n=0.681$; $C=72.2$	0–15.0	4
“ . .	1969.	–	$n=0.6852$; $C=80.3$	15.3–99.6	3
“ . .	2348.	–	$n=0.6771$	99.6–184.6	3
Hydrogen . .	857.4	.00366	$C=71.7$	–	2
“ . .	–	–	$n=0.681$; $C=72.2$	–	4
Mercury . .	1620.	.003665	$n=1.6$	273–380	10
Nitrogen . .	1658.6	.003665	$\beta=0.00269$; $n=0.738$	–21.5–53.5	7
Nitrous oxide .	1353.3	.003719	$\beta=0.00345$; $n=0.929$	–21.5–100.3	“
Oxygen . .	–	–	$n=0.782$; $C=128.2$	–	4

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Compiled from Landolt-Börnstein-Meyerhoffer's Physikalisch-chemische Tabellen.

TABLE 117.

DIFFUSION OF AN AQUEOUS SOLUTION INTO PURE WATER.

If k is the coefficient of diffusion, dS the amount of the substance which passes in the time dt, at the place x, through q sq. cm. of a diffusion cylinder under the influence of a drop of concentration dc/dx, then

$$dS = -kq\frac{dc}{dx}dt.$$

k depends on the temperature and the concentration. c gives the gram-molecules per litre. The unit of time is a day.

Substance.	c	$t°$	k	Reference	Substance.	c	$t°$	k	Reference.
Bromine . . .	0.1	12.	0.8	1	Calcium chloride .	0.864	8.5	0.70	4
Chlorine . . .	“	12.	1.22	“	“ “ . .	1.22	9.	0.72	“
Copper sulphate .	“	17.	0.39	2	“ “ . .	0.060	9.	0.64	“
Glycerine . .	“	10.14	0.357	3	“ “ . .	0.047	9.	0.68	“
Hydrochloric acid .	“	19.2	2.21	2	Copper sulphate .	1.95	17.	0.23	2
Iodine . . .	“	12.	(0.5)	1	“ “ . .	0.95	17.	0.26	“
Nitric acid . .	“	19.5	2.07	2	“ “ . .	0.30	17.	0.33	“
Potassium chloride .	“	17.5	1.38	2	“ “ . .	0.005	17.	0.47	“
“ hydrate .	“	13.5	1.72	2	Glycerine . .	2/8	10.14	0.354	3
Silver nitrate . .	“	12.	0.985	2	“ . . .	6/8	10.14	0.345	“
Sodium chloride .	“	15.0	0.94	2	“ . . .	10/8	10.14	0.329	“
Urea . . .	“	14.8	0.97	3	“ . . .	14/8	10.14	0.300	“
Acetic acid . .	0.2	13.5	0.77	4	Hydrochloric acid .	4.52	11.5	2.93	4
Barium chloride .	“	8.	0.66	4	“ “ .	3.16	11.	2.67	“
Glycerine . .	“	10.1	3.55	3	“ “ ,	0.945	11.	2.12	“
Sodium actetate .	“	12.	0.67	5	“ “ .	0.387	11.	2.02	“
“ chloride .	“	15.0	0.94	2	“ “ .	0.250	11.	1.84	“
Urea . . .	“	14.8	0.969	3	Magnesium sulphate	2.18	5.5	0.28	4
Acetic acid . .	1.0	12.	0.74	6	“ “ .	0.541	5.5	0.32	“
Ammonia . .	“	15.23	1.54	7	“ “ .	3.23	10.	0.27	“
Formic acid . .	“	12.	0.97	7	“ “ .	0.402	10.	0.34	“
Glycerine . .	“	10.14	0.339	3	Potassium hydrate .	0.75	12.	1.72	6
Hydrochloric acid .	“	12.	2.09	6	“ “ .	0.49	12.	1.70	“
Magnesium sulphate	“	7.	0.30	4	“ “ .	0.375	12.	1.70	“
Potassium bromide .	“	10.	1.13	8	“ nitrate .	3.9	17.6	0.89	2
“ hydrate .	“	12.	1.72	6	“ “ .	1.4	17.6	1.10	“
Sodium chloride .	“	15.0	0.94	2	“ “ .	0.3	17.6	1.26	“
“ “ . .	“	14.3	0.964	3	“ “ .	0.02	17.6	1.28	“
“ hydrate .	“	12.	1.11	2	“ sulphate	0.95	19.6	0.79	“
“ iodide .	“	10.	0.80	8	“ “ .	0.28	19.6	0.86	“
Sugar . . .	“	12.	0.254	6	“ “ .	0.05	19.6	0.97	“
Sulphuric acid .	“	12.	1.12	6	“ “ .	0.02	19.6	1.01	“
Zinc sulphate . .	“	14.8	0.236	9	Silver nitrate . .	3.9	12.	0.535	“
Acetic acid . .	2.0	12.	0.69	6	“ “ . .	0.9	12.	0.88	“
Calcium chloride .	“	10.	0.68	8	“ “ . .	0.02	12.	1.035	“
Cadmium sulphate .	“	19.04	0.246	9	Sodium chloride .	2/8	14.33	1.013	3
Hydrochloric acid .	“	12.	2.21	6	“ “ . .	4/8	14.33	0.996	“
Sodium iodide .	“	10.	0.90	8	“ “ . .	6/8	14.33	0.980	2
Sulphuric acid .	“	12.	1.16	6	“ “ . .	10/8	14.33	0.948	“
Zinc acetate . .	“	18.05	0.210	9	“ “ . .	14/8	14.33	0.917	“
“ “ . .	“	0.04	0.120	9	Sulphuric acid .	9.85	18.	2.36	2
Acetic acid . .	3.0	12.	0.68	–	“ “ . .	4.85	18.	1.90	“
Potassium carbonate	“	10.	0.60	8	“ “ . .	2.85	18.	1.60	“
“ hydrate .	“	12.	1.89	6	“ “ . .	0.85	18.	1.34	“
Acetic acid . .	4.0	12.	0.66	6	“ “ . .	0.35	18.	1.32	“
Potassium chloride .	“	10.	1.27	8	“ “ . .	0.005	18.	1.30	“

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Compiled from Landolt-Börnstein-Meyerhoffer's Physikalisch-chemische Tabellen.

TABLE 118.

DIFFUSION OF VAPORS.

Coefficients of diffusion of vapors in C. G. S. units. The coefficients are for the temperatures given in the table and a pressure of 76 centimetres of mercury.*

Vapor.	Temp. C. °	k_t for vapor diffusing into hydrogen.	k_t for vapor diffusing into air.	k_t for vapor diffusing into carbon dioxide.
Acids: Formic	0.0	0.5131	0.1315	0.0879
"	65.4	0.7873	0.2035	0.1343
"	84.9	0.8830	0.2244	0.1519
Acetic	0.0	0.4040	0.1061	0.0713
"	65.5	0.6211	0.1578	0.1048
"	98.5	0.7481	0.1965	0.1321
Isovaleric	0.0	0.2118	0.0555	0.0375
"	98.0	0.3934	0.1031	0.0696
Alcohols: Methyl	0.0	0.5001	0.1325	0.0880
"	25.6	0.6015	0.1620	0.1046
"	49.6	0.6738	0.1809	0.1234
Ethyl	0.0	0.3806	0.0994	0.0693
"	40.4	0.5030	0.1372	0.0898
"	66.9	0.5430	0.1475	0.1026
Propyl	0.0	0.3153	0.0803	0.0577
"	66.9	0.4832	0.1237	0.0901
"	83.5	0.5434	0.1379	0.0976
Butyl	0.0	0.2716	0.0681	0.0476
"	99.0	0.5045	0.1265	0.0884
Amyl	0.0	0.2351	0.0589	0.0422
"	99.1	0.4362	0.1094	0.0784
Hexyl	0.0	0.1998	0.0499	0.0351
"	99.0	0.3712	0.0927	0.0651
Benzene	0.0	0.2940	0.0751	0.0527
"	19.9	0.3409	0.0877	0.0609
"	45.0	0.3993	0.1011	0.0715
Carbon disulphide	0.0	0.3690	0.0883	0.0629
" "	19.9	0.4255	0.1015	0.0726
" "	32.8	0.4626	0.1120	0.0789
Esters: Methyl acetate	0.0	0.3277	0.0840	0.0557
" "	20.3	0.3928	0.1013	0.0679
Ethyl "	0.0	0.2373	0.0630	0.0450
" "	46.1	0.3729	0.0970	0.0666
Methyl butyrate	0.0	0.2422	0.0640	0.0438
" "	92.1	0.4308	0.1139	0.0809
Ethyl "	0.0	0.2238	0.0573	0.0406
" "	96.5	0.4112	0.1064	0.0756
" valerate	0.0	0.2050	0.0505	0.0366
" "	97.6	0.3784	0.0932	0.0676
Ether	0.0	0.2960	0.0775	0.0552
"	19.9	0.3410	0.0893	0.0636
Water	0.0	0.6870	0.1980	0.1310
"	49.5	1.0000	0.2827	0.1811
"	92.4	1.1794	0.3451	0.2384

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* Taken from Winkelmann's papers (Wied. Ann. vols. 22, 23, and 26). The coefficients for 0° were calculated by Winkelmann on the assumption that the rate of diffusion is proportional to the absolute temperature. According to the investigations of Loschmidt and of Obermeyer the coefficient of diffusion of a gas, or vapor, at 0° C. and a pressure of 76 centimetres of mercury may be calculated from the observed coefficient at another temperature and pressure by the formula $k_0 = k_T \left(\frac{T_0}{T}\right)^n \frac{76}{p}$, where T is temperature absolute and p the pressure of the gas. The exponent n is found to be about 1.75 for the permanent gases and about 2 for condensible gases. The following are examples: Air — CO_2, $n = 1.968$; CO_2 — N_2O, $n = 2.05$; CO_2 — H, $n = 1.742$; CO — O, $n = 1.785$; H — O, $n = 1.755$; O — N, $n = 1.792$. Winkelmann's results, as given in the above table, seem to give about 2 for vapors diffusing into air, hydrogen or carbon dioxide.

DIFFUSION OF GASES, VAPORS, AND METALS.

TABLE 119. — Coefficients of Diffusion for Various Gases and Vapors.*

Gas or Vapor diffusing.	Gas or Vapor diffused into.	Temp. ° C.	Coefficient of Diffusion.	Authority.
Air	Hydrogen	0	0.661	Schulze.
"	Oxygen	0	0.1775	Obermayer.
Carbon dioxide	Air	0	0.1423	Loschmidt.
" "	"	0	0.1360	Waitz.
" "	Carbon monoxide	0	0.1405	Loschmidt.
" "	" "	0	0.1314	Obermayer.
" "	Hydrogen	0	0.5437	"
" "	Methane	0	0.1465	"
" "	Nitrous oxide	0	0.0983	Loschmidt.
" "	Oxygen	0	0.1802	"
Carbon disulphide	Air	0	0.0995	Stefan.
Carbon monoxide	Carbon dioxide	0	0.1314	Obermayer.
" "	Ethylene	0	0.101	"
" "	Hydrogen	0	0.6422	Loschmidt.
" "	Oxygen	0	0.1802	"
" "	"	0	0.1872	Obermayer.
Ether	Air	0	0.0827	Stefan.
"	Hydrogen	0	0.3054	"
Hydrogen	Air	0	0.6340	Obermayer.
"	Carbon dioxide	0	0.5384	"
"	" monoxide	0	0.6488	"
"	Ethane	0	0.4593	"
"	Ethylene	0	0.4863	"
"	Methane	0	0.6254	"
"	Nitrous oxide	0	0.5347	"
"	Oxygen	0	0.6788	"
Nitrogen	"	0	0.1787	"
Oxygen	Carbon dioxide	0	0.1357	"
"	Hydrogen	0	0.7217	Loschmidt.
"	Nitrogen	0	0.1710	Obermayer.
Sulphur dioxide	Hydrogen	0	0.4828	Loschmidt.
Water	Air	8	0.2390	Guglilemo.
"	"	18	0.2475	"
"	Hydrogen	18	0.8710	"

* Compiled for the most part from a similar table in Landolt & Börnstein's Phys. Chem. Tab.

TABLE 119 A. — Diffusion of Metals into Metals.

$\frac{dv}{dt} = k\frac{d^2v}{dx^2}$; where x is the distance in direction of diffusion; v, the degree of concentration of the diffusing metal; t, the time; k, the diffusion constant = the quantity of metal in grammes diffusing through a sq. cm. in a day when unit difference of concentration (gr. per cu. cm.) is maintained between two sides of a layer one cm. thick.

Diffusing Metal.	Dissolving Metal.	Temperature ° C.	k.	Diffusing Metal.	Dissolving Metal.	Temperature ° C.	k.
Gold	Lead	555	3.19	Platinum	Lead	492	1.69
"	"	492	3.00	Lead	Tin	555	3.18
"	"	251	0.03	Rhodium	Lead	550	3.04
"	"	200	0.008	Tin	Mercury	15	1.22*
"	"	165	0.004	Lead	"	15	1.0*
"	"	100	0.00002	Zinc	"	15	1.0*
"	Bismuth	555	4.52	Sodium	"	15	0.45*
"	Tin	555	4.65	Potassium	"	15	0.40*
Silver	"	555	4.14	Gold	"	15	0.72*

From Roberts-Austen, Philosophical Transactions, 1896 A.

* These values are from Guthrie.

TABLE 120.

SOLUBILITY OF INORGANIC SALTS IN WATER; VARIATION WITH THE TEMPERATURE.

The numbers give the number of grammes of the *anhydrous* salt soluble in 1000 grammes of water at the given temperatures.

Salt.	Temperature Centigrade.										
	0°	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°
$AgNO_3$	1150	1600	2150	2700	3350	4000	4700	5500	6500	7600	9100
$Al_2(SO_4)_3$	313	335	362	404	457	521	591	662	731	808	891
$Al_2K_2(SO_4)_4$	30	–	–	84	–	–	248	–	–	–	1540
$Al_2(NH_4)_2(SO_4)_4$	26	45	66	91	124	159	211	270	352	–	–
B_2O_3	11	15	22	–	40	–	62	–	95	–	157
$BaCl_2$	316	333	357	382	408	436	464	494	524	556	588
$Ba(NO_3)_2$	50	70	92	116	142	171	203	236	270	306	342
$CaCl_2$	595	650	745	1010	1153	–	1368	1417	1470	1527	1590
$CoCl_2$	405	450	500	565	650	935	940	950	960	–	1030
$CsCl$	1614	1747	1865	1973	2080	2185	2290	2395	2500	2601	2705
$CsNO_3$	93	149	230	339	472	644	838	1070	1340	1630	1970
Cs_2SO_4	1671	1731	1787	1841	1899	1949	1999	2050	2103	2149	2203
$Cu(NO_3)_2$	818	–	1250		1598	–	1791	–	2078	–	
$CuSO_4$	149	–	–	255	295	336	390	457	535	627	735
$FeCl_2$	–	–	685	–	–	820	–	–	1040	1050	1060
Fe_2Cl_6	744	819	918	–	–	3151	–	–	5258	–	5357
$FeSO_4$	156	208	264	330	402	486	550	560	506	430	–
$HgCl_2$	43	66	74	84	96	113	139	173	243	371	540
KBr	540	–	650	–	760	–	860	–	955	–	1050
K_2CO_3	1050	–	–	1140	1170	1210	1270	1330	1400	1470	1560
KCl	285	312	343	373	401	429	455	483	510	538	566
$KClO_3$	33	50	71	101	145	197	260	325	396	475	560
K_2CrO_4	589	609	629	650	670	690	710	730	751	771	791
$K_2Cr_2O_7$	50	85	131	–	292	-	505	–	730	–	1020
$KHCO_3$	225	277	332	390	453	522	600	–	–	–	–
KI	1279	1361	1442	1523	1600	1680	1760	1840	1920	2010	2090
KNO_3	133	209	316	458	639	855	1099	1380	1690	2040	2460
KOH	970	1030	1120	1260	1360	1400	1460	1510	1590	1680	1780
K_2PtCl_6	7	9	11	14	18	22	26	32	38	45	52
K_2SO_4	74	92	111	130	148	165	182	198	214	228	241
$LiOH$	127	127	128	129	130	133	138	144	153	–	175
$MgCl_2$	528	535	545	–	575	–	610		660	–	730
$MgSO_4$ (7aq)	260	309	356	409	456	–	–		–	–	–
" (6aq)	408	422	439	453	–	504	550	596	642	689	738
NH_4Cl	297	333	372	414	458	504	552	602	656	713	773
NH_4HCO_3	119	159	210	270	–	–	–	–	–	–	–
NH_4NO_3	1183	–	–	2418	2970	3540?	4300?	5130?	5800	7400	8710
$(NH_4)_2SO_4$	706	730	754	780	810	844	880	916	953	992	1033
$NaBr$	795	845	903	–	1058	1160	1170	–	1185	–	1205
$Na_2B_4O_7$	–	16	–	39	–	105	200	244	314	408	523
Na_2CO_3 (10aq)	71	126	214	409	–	–	-	–	–	–	–
" (7aq)	204	263	335	435	(1aq)	475	464	458	452	452	452
$NaCl$	356	357	358	360	363	367	371	375	380	385	391
$NaClO_3$	820	890	990	–	1235	–	1470	–	1750	–	2040
Na_2CrO_4	317	502	900	–	960	1050	1150	–	1240	–	1260
$Na_2Cr_2O_7$	1630	1700	1800	1970	2200	2480	2830	3230	3860	–	4330
$NaHCO_3$	69	82	96	111	127	145	164	–	–	–	–
Na_2HPO_4	25	39	93	241	639	–		949	–	–	988
NaI	1590	1690	1790	1900	2050	2280	2570	–	2950	–	3020
$NaNO_3$	730	805	880	962	1049	1140	1246	1360	1480	1610	1755

Compiled from Landolt-Börnstein-Meyerhoffer's Physikalisch-chemische Tabellen.

SOLUBILITY OF SALTS AND GASES IN WATER.

TABLE 120 (*continued*). — Solubility of Inorganic Salts in Water; Variation with the Temperature.

The numbers give the number of grammes of the *anhydrous* salt soluble in 1000 grammes of water at the given temperatures.

Salt.	Temperature Centigrade.										
	0°	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°
$NaOH$	420	515	1090	1190	1290	1450	1740	–	3130	–	–
$Na_4P_2O_7$	32	39	62	99	135	174	220	255	300	–	–
Na_2SO_3	141	–	287	–	495	–	–	–	–	–	330
Na_2SO_4 (10aq)	50	90	194	400	482	468	455	445	437	429	427
" (7aq)	196	305	447	–							
$Na_2S_2O_3$	525	610	700	847	1026	1697	2067	–	2488	2542	2660
$NiCl_2$	–	600	640	680	720	760	810	–	–	–	–
$NiSO_4$	272	–	–	425	–	502	548	594	632	688	776
$PbBr_2$	5	6	8	12	15	20	24	28	33	–	48
$Pb(NO_3)_2$	365	444	523	607	694	787	880	977	1076	1174	1270
$RbCl$	770	844	911	976	1035	1093	1155	1214	1272	1331	1389
$RbNO_3$	195	330	533	813	1167	1556	2000	2510	3090	3750	5420
Rb_2SO_4	364	426	482	535	585	631	674	714	750	787	818
$SrCl_2$	442	483	539	600	667	744	831	896	924	962	1019
SnI_2	–	–	10	12	14	17	21	25	30	34	40
$Sr(NO_3)_2$	395	549	708	876	913	926	940	956	972	990	1011
$Th(SO_4)_2$ (9aq)	7	10	14	20	30	51	–	–	–	–	–
" (4aq)	–	–		–	40	25	16	11	–	–	–
$TlCl$	2	2	3	5	6	8	10	13	16	20	–
$TlNO_3$	39	62	96	143	209	304	462	695	1110	2000	4140
Tl_2SO_4	27	37	49	62	76	92	109	127	146	165	–
$Yb_2(SO_4)_3$	442	–	–	–	–	–	104	72	69	58	47
$Zn(NO_3)_2$	948	–	–	–	2069	–	–	–	–	–	–
$ZnSO_4$	–	–	–	–	700	768	–	890	860	920	785

TABLE 121. — Solubility of a Few Organic Salts in Water; Variation with the Temperature.

Salt.	0°	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°
$H_2(CO_2)_2$	36	53	102	159	228	321	445	635	978	1200	–
$H_2(CH_2.CO_2)_2$	28	45	69	106	162	244	358	511	708	–	1209
Tartaric acid	1150	1260	1390	1560	1760	1950	2180	2440	2730	3070	3430
Racemic "	92	140	206	291	433	595	783	999	1250	1530	1850
$K(HCO_2)$	2900	–	3350	–	3810	–	4550	–	5750	–	7900
$KH(C_4H_4O_4)$	3	4	6	9	13	18	24	32	45	57	69

TABLE 122. — Solubility of Gases in Water; Variation with the Temperature.

The table gives the weight in grammes of the gas which will be absorbed in 1000 grammes of water when the partial pressure of the gas plus the vapor pressure of the liquid at the given temperature equals 760 mm.

Gas.	0°	10°	20°	30°	40°	50°	60°	70°	80°
O_2	.0705	.0551	.0443	.0368	.0311	.0263	.0221	.0181	.0135
H_2	.00192	.00174	.00160	.00147	.00138	.00129	.00118	.00102	.00079
N_2	.0293	.0230	.0189	.0161	.0139	.0121	.0105	.0089	.0069
Br_2	431.	248.	148.	94.	62.	40.	28.	18.	11.
Cl_2	–	9.97	7.29	5.72	4.59	3.93	3.30	2.79	2.23
CO_2	3.35	2.32	1.69	1.26	0.97	0.76	0.58	–	–
H_2S	7.10	5.30	3.98	–	–	–	–	–	–
NH_3	987.	689.	535.	422.	–	–	–	–	–
SO_2	228.	162.	113.	78.	54.	–	–	–	–

Compiled from Landolt-Börnstein-Meyerhoffer's Physikalisch-chemische Tabellen.

TABLE 123.

ABSORPTION OF GASES BY LIQUIDS.*

Temperature Centigrade. t	ABSORPTION COEFFICIENTS, a_t, FOR GASES IN WATER.						
	Carbon dioxide. CO_2	Carbon monoxide. CO	Hydrogen. H	Nitrogen. N	Nitric oxide. NO	Nitrous oxide. N_2O	Oxygen. O
0	1.797	0.0354	0.02110	0.02399	0.0738	1.048	0.04925
5	1.450	.0315	.02022	.02134	.0646	0.8778	.04335
10	1.185	.0282	.01944	.01918	.0571	0.7377	.03852
15	1.002	.0254	.01875	.01742	.0515	0.6294	.03456
20	0.901	.0232	.01809	.01599	.0471	0.5443	.03137
25	0.772	.0214	.01745	.01481	.0432	–	.02874
30	–	.0200	.01690	.01370	.0400	–	.02646
40	0.506	.0177	.01644	.01195	.0351	–	.02316
50	–	.0161	.01608	.01074	.0315	–	.02080
100	0.244	.0141	.01600	.01011	.0263	–	.01690

Temperature Centigrade. t	Air.	Ammonia. NH_3	Chlorine. Cl	Ethylene. C_2H_4	Methane. CH_4	Hydrogen sulphide. H_2S	Sulphur dioxide. SO_2
0	0.02471	1174.6	3.036	0.2563	0.05473	4.371	79.79
5	.02179	971.5	2.808	.2153	.04889	3.965	67.48
10	.01953	840.2	2.585	.1837	.04367	3.586	56.65
15	.01795	756.0	2.388	.1615	.03903	3.233	47.28
20	.01704	683.1	2.156	.1488	.03499	2.905	39.37
25	–	610.8	1.950	–	.02542	2.604	32.79

Temperature Centigrade. t	ABSORPTION COEFFICIENTS, a_t, FOR GASES IN ALCOHOL, C_2H_5OH.								
	Carbon dioxide. CO_2	Ethylene. C_2H_4	Methane. CH_4	Hydrogen. H	Nitrogen. N	Nitric oxide. NO	Nitrous oxide. N_2O	Hydrogen sulphide. H_2S	Sulphur dioxide. SO_2
0	4.329	3.595	0.5226	0.0692	0.1263	0.3161	4.190	17.89	328.6
5	3.891	3.323	.5086	.0685	.1241	.2998	3.838	14.78	251.7
10	3.514	3.086	.4953	.0679	.1228	.2861	3.525	11.99	190.3
15	3.199	2.882	.4828	.0673	.1214	.2748	3.215	9.54	144.5
20	2.946	2.713	.4710	.0667	.1204	.2659	3.015	7.41	114.5
25	2.756	2.578	.4598	.0662	.1196	.2595	2.819	5.62	99.8

* This table contains the volumes of different gases, supposed measured at 0° C. and 76 centimetres' pressure, which unit volume of the liquid named will absorb at atmospheric pressure and the temperature stated in the first column. The numbers tabulated are commonly called the absorption coefficients for the gases in water, or in alcohol, at the temperature t and under one atmosphere of pressure. The table has been compiled from data published by Bohr & Bock, Bunsen, Carius, Dittmar, Hamberg, Henrick, Pagliano & Emo, Raoult, Schönfeld, Setschenow, and Winkler. The numbers are in many cases averages from several of these authorities.

NOTE. — The effect of increase of pressure is generally to increase the absorption coefficient. The following is approximately the magnitude of the effect in the case of ammonia in alcohol at a temperature of 23° C.:

P	= 45 cms.	50 cms.	55 cms.	60 cms.	65 cms.
a_{23}	= 69	74	79	84	88

According to Setschenow the effect of varying the pressure from 45 to 85 centimetres in the case of carbonic acid in water is very small.

CAPILLARITY.—SURFACE TENSION OF LIQUIDS.*

TABLE 124.—Water and Alcohol in Contact with Air.

Temp. C.	Surface tension in dynes per centimetre.		Temp. C.	Surface tension in dynes per centimetre.		Temp. C.	Surface tension in dynes per centimetre.
	Water.	Ethyl alcohol.		Water.	Ethyl alcohol.		Water.
0°	75.6	23.5	40°	70.0	20.0	80°	64.3
5	74.9	23.1	45	69.3	19.5	85	63.6
10	74.2	22.6	50	68.6	19.1	90	62.9
15	73.5	22.2	55	67.8	18.6	95	62.2
20	72.8	21.7	60	67.1	18.2	100	61.5
25	72.1	21.3	65	66.4	17.8	–	–
30	71.4	20.8	70	65.7	17.3	–	–
35	70.7	20.4	75	65.0	16.9	–	–

TABLE 125.—Miscellaneous Liquids in Contact with Air.

Liquid.	Temp. C.°	Surface tension in dynes per centimetre.	Authority.
Aceton	16.8	23.3	Ramsay-Shields.
Acetic acid . . .	17.0	30.2	Average of various.
Amyl alcohol . .	15.0	24.8	"
Benzene	15.0	28.8	"
Butyric acid . .	15.0	28.7	"
Carbon disulphide	20.0	30.5	Quincke.
Chloroform . .	20.0	28.3	Average of various.
Ether	20.0	18.4	"
Glycerine . . .	17.0	63.14	Hall.
Hexane	0.0	21.2	Schiff.
"	68.0	14.2	"
Mercury	18.0	520.0	Average of various.
Methyl alcohol .	15.0	24.7	"
Olive oil	20.0	34.7	"
Petroleum . . .	20.0	25.9	Magie.
Propyl alcohol .	5.8	25.9	Schiff.
" " . .	97.1	18.0	"
Toluol	15.0	29.1	"
"	109.8	18.9	"
Turpentine . . .	21.0	28.5	Average of various.

TABLE 126.—Solutions of Salts in Water.†

Salt in solution.	Density.	Temp. C.°	Tension in dynes per cm.
$BaCl_2$	1.2820	15–16	81.8
"	1.0497	15–16	77.5
$CaCl_2$	1.3511	19	95.0
"	1.2773	19	90.2
HCl	1.1190	20	73.6
"	1.0887	20	74.5
"	1.0242	20	75.3
KCl	1.1699	15–16	82.8
"	1.1011	15–16	80.1
"	1.0463	15–16	78.2
$MgCl_2$	1.2338	15–16	90.1
"	1.1694	15–16	85.2
"	1.0362	15–16	78.0
NaCl	1.1932	20	85.8
"	1.1074	20	80.5
"	1.0360	20	77.6
NH_4Cl	1.0758	16	84.3
"	1.0535	16	81.7
"	1.0281	16	78.8
$SrCl_2$	1.3114	15–16	85.6
"	1.1204	15–16	79.4
"	1.0567	15–16	77.8
K_2CO_3	1.3575	15–16	90.9
"	1.1576	15–16	81.8
"	1.0400	15–16	77.5
Na_2CO_3	1.1329	14–15	79.3
"	1.0605	14–15	77.8
"	1.0283	14–15	77.2
KNO_3	1.1263	14	78.9
"	1.0466	14	77.6
$NaNO_3$	1.3022	12	83.5
"	1.1311	12	80.0
$CuSO_4$	1.1775	15–16	78.6
"	1.0276	15–16	77.0
H_2SO_4	1.8278	15	63.0?
"	1.4453	15	79.7
"	1.2636	15	79.7
K_2SO_4	1.0744	15–16	78.0
"	1.0360	15–16	77.4
$MgSO_4$	1.2744	15–16	83.2
"	1.0680	15–16	77.8
Mn_2SO_4	1.1119	15–16	79.1
"	1.0329	15–16	77.3
$ZnSO_4$	1.3981	15–16	83.3
"	1.2830	15–16	80.7
"	1.1039	15–16	77.8

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* This determination of the capillary constants of liquids has been the subject of many careful experiments, but the results of the different experimenters, and even of the same observer when the method of measurement is changed, do not agree well together. The values here quoted can only be taken as approximations to the actual values for the liquids in a state of purity in contact with pure air. In the case of water the values given by Lord Rayleigh from the wave length of ripples (Phil. Mag. 1890) and by Hall from direct measurement of the tension of a flat film (Phil. Mag. 1893) have been preferred, and the temperature correction has been taken as 0.141 dyne per degree centigrade. The values for alcohol were derived from the experiments of Hall above referred to and the experiments on the effect of temperature made by Timberg (Wied. Ann. vol. 30).

The authority for a few of the other values given is quoted, but they are for the most part average values derived from a large number of results published by different experimenters.

† From Volkmann (Wied. Ann. vol. 17, p. 353).

TENSION OF LIQUIDS.

TABLE 127. — Surface Tension of Liquids.*

Liquid.	Specific gravity.	Surface tension in dynes per centimetre of liquid in contact with —		
		Air.	Water.	Mercury.
Water	1.0	75.0	0.0	(392)
Mercury	13.543	513.0	392.0	0
Bisulphide of carbon	1.2687	30.5	41.7	(387)
Chloroform	1.4878	(31.8)	26.8	(415)
Ethyl alcohol	0.7906	(24.1)	–	364
Olive oil	0.9136	34.6	18.6	317
Turpentine	0.8867	28.8	11.5	241
Petroleum	9.7977	29.7	(28.9)	271
Hydrochloric acid	1.10	(72.9)	–	(392)
Hyposulphite of soda solution	1.1248	69.9	–	429

TABLE 128. — Surface Tension of Liquids at Solidifying Point.†

Substance.	Temperature of solidification. Cent.°	Surface tension in dynes per centimetre.	Substance.	Temperature of solidification. Cent.°	Surface tension in dynes per centimetre.
Platinum	2000	1691	Antimony	432	249
Gold	1200	1003	Borax	1000	216
Zinc	360	877	Carbonate of soda	1000	210
Tin	230	599	Chloride of sodium	–	116
Mercury	—40	588	Water	0	87.9‡
Lead	330	457	Selenium	217	71.8
Silver	1000	427	Sulphur	111	42.1
Bismuth	265	1390	Phosphorus	43	42.0
Potassium	58	371	Wax	68	34.1
Sodium	90	258			

TABLE 129. — Tension of Soap Films.

Elaborate measurements of the thickness of soap films have been made by Reinold and Rucker.‖ They find that a film of oleate of soda solution containing 1 of soap to 70 of water, and having 3 per cent of KNO_3 added to increase electrical conductivity, breaks at a thickness varying between 7.2 and 14.5 micro-millimetres, the average being 12.1 micro-millimetres. The film becomes black and apparently of nearly uniform thickness round the point where fracture begins. Outside the black patch there is the usual display of colors, and the thickness at these parts may be estimated from the colors of thin plates and the refractive index of the solution (*vide* Newton's rings, Table 146).

When the percentage of KNO_3 is diminished, the thickness of the black patch increases.

For example, KNO_3 = 3 1 0.5 0.0
Thickness = 12.4 13.5 14.5 22.1 micro-mm.

A similar variation was found in the other soaps.

It was also found that diminishing the proportion of soap in the solution, there being no KNO_3 dissolved, increased the thickness of the film.

1 part soap to 30 of water gave thickness 21.6 micro-mm.
1 part soap to 40 of water gave thickness 22.1 micro-mm.
1 part soap to 60 of water gave thickness 27.7 micro-mm.
1 part soap to 80 of water gave thickness 29.3 micro-mm.

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* This table of tensions at the surface separating the liquid named in the first column and air, water or mercury as stated at the head of the last three columns, is from Quincke's experiments (Pogg. Ann. vol. 139, and Phil. Mag. 1871). The numbers given are the equivalent in dynes per centimetre of those obtained by Worthington from Quincke's results (Phil. Mag. vol. 20, 1885) with the exception of those in brackets, which were not corrected by Worthington; they are probably somewhat too high, for the reason stated by Worthington. The temperature was about 20° C.

† Quincke, "Pogg. Ann." vol. 135, p. 661.

‡ It will be observed that the value here given on the authority of Quincke is much higher than his subsequent measurements, as quoted above, give.

‖ "Proc. Roy. Soc." 1877, and "Phil. Trans. Roy. Soc." 1881, 1883, and 1893.

NOTE. — Quincke points out that substances may be divided into groups in each of which the ratio of the surface tension to the density is nearly constant. Thus, if this ratio for mercury be taken as unit, the ratio for the bromides and iodides is about a half: that of the nitrates, chlorides, sugars, and fats, as well as the metals, lead, bismuth, and antimony, about 1; that of water, the carbonates, sulphates, and probably phosphates, and the metals platinum, gold, silver, cadmium, tin, and copper, 2; that of zinc, iron, and palladium, 3; and that of sodium, 6.

TABLE 130.

VAPOR PRESSURES.

The vapor pressures here tabulated have been taken, with one exception, from Regnault's results. The vapor pressure of Pictet's fluid is given on his own authority. The pressures are in centimetres of mercury.

Temperature Cent.	Acetone. C_3H_6O	Benzol. C_6H_6	Carbon bisulphide. CS_2	Carbon tetrachloride. CCl_4	Chloroform. $CHCl_3$	Ethyl alcohol. C_2H_6O	Ethyl ether. $C_4H_{10}O$	Ethyl bromide. C_2H_5Br	Methyl alcohol. CH_4O	Turpentine. $C_{10}H_{16}$
—25°	–	–	–	–	–	–	–	4.41	.41	–
—20	–	.58	4.73	.98	–	.33	6.89	5.92	.63	–
—15	–	.88	6.16	1.35	–	.51	8.93	7.81	.93	–
—10	–	1.29	7.94	1.85	–	.65	11.47	10.15	1.35	–
—5	–	1.83	10.13	2.48	–	.91	14.61	13.06	1.92	–
0	–	2.53	12.79	3.29	5.97	1.27	18.44	16.56	2.68	.21
5	–	3.42	16.00	4.32	–	1.76	23.09	20.72	3.69	–
10	–	4.52	19.85	5.60	10.05	2.42	28.68	25.74	5.01	.29
15	–	5.89	24.41	7.17	–	3.30	35.36	31.69	6.71	–
20	17.96	7.56	29.80	9.10	16.05	4.45	43.28	38.70	8.87	.44
25	22.63	9.59	36.11	11.43	20.02	5.94	52.59	46.91	11.60	–
30	28.10	12.02	43.46	14.23	24.75	7.85	63.48	56.45	15.00	.69
35	34.52	14.93	51.97	17.55	30.35	10.29	76.12	67.49	19.20	–
40	42.01	18.36	61.75	21.48	36.93	13.37	90.70	80.19	24.35	1.08
45	50.75	22.41	72.95	26.08	44.60	17.22	107.42	94.73	30.61	–
50	62.29	27.14	85.71	31.44	53.50	21.99	126.48	111.28	38.17	1.70
55	72.59	32.64	100.16	37.63	63.77	27.86	148.11	130.03	47.22	–
60	86.05	39.01	116.45	44.74	75.54	35.02	172.50	151.19	57.99	2.65
65	101.43	46.34	134.75	52.87	88.97	43.69	199.89	174.95	70.73	–
70	118.94	54.74	155.21	62.11	104.21	54.11	230.49	201.51	85.71	4.06
75	138.76	64.32	177.99	72.57	121.42	66.55	264.54	231.07	103.21	–
80	161.10	75.19	203.25	84.33	140.76	81.29	302.28	263.86	123.85	6.13
85	186.18	87.46	231.17	97.51	162.41	98.64	343.95	300.06	147.09	–
90	214.17	101.27	261.91	112.23	186.52	118.93	389.83	339.89	174.17	9.06
95	245.28	116.75	296.63	128.69	213.28	142.51	440.18	383.55	205.17	–
100	279.73	134.01	332.51	146.71	242.85	169.75	495.33	431.23	240.51	13.11
105	317.70	153.18	372.72	166.72	275.40	201.04	555.62	483.12	280.63	–
110	359.40	174.44	416.41	188.74	311.10	236.76	621.46	539.40	325.96	18.60
115	405.00	197.82	463.74	212.91	350.10	277.34	693.33	600.24	376.98	–
120	454.69	223.54	514.88	239.37	392.57	323.17	771.92	665.80	434.18	25.70
125	508.62	251.71	569.97	268.24	438.66	374.69	–	736.22	498.05	–
130	566.97	282.43	629.16	299.69	488.51	432.30	–	811.65	569.13	34.90
135	629.87	315.85	692.59	333.86	542.25	496.42	–	892.19	647.93	–
140	697.44	352.07	760.40	370.90	600.02	567.46	–	977.96	733.71	46.40
145	–	391.21	832.69	411.00	661.92	645.80	–	–	830.89	–
150	–	433.37	909.59	454.31	728.06	731.84	–	–	936.13	60.50
155	–	478.65	–	501.02	798.53	825.92	–	–	–	68.60
160	–	527.14	–	551.31	873.42	–	–	–	–	77.50
165	–	568.30	–	605.38	952.78	–	–	–	–	–
170	–	634.07	–	663.44	–	–	–	–	–	–

VAPOR PRESSURES.

Temperature, Centigrade.	Ammonia. NH_3	Carbon dioxide. CO_2	Ethyl chloride. C_2H_5Cl	Ethyl iodide. C_2H_5I	Methyl chloride. CH_3Cl	Methylic ether. C_2H_6O	Nitrous oxide. N_2O	Pictet's fluid. $64SO_2+44CO_2$ by weight	Sulphur dioxide. SO_2	Hydrogen sulphide. H_2S
—30°	86.61	-	11.02	-	57.90	57.65	-	58.52	28.75	-
—25	110.43	1300.70	14.50	-	71.78	71.61	1569.49	67.64	37.38	374.93
—20	139.21	1514.24	18.75	-	88.32	88.20	1758.66	74.48	47.95	443.85
—15	173.65	1758.25	23.96	-	107.92	107.77	1968.43	89.68	60.79	519.65
—10	214.46	2034.02	30.21	-	130.96	130.66	2200.80	101.84	76.25	608.46
—5	264.42	2344.13	37.67	-	157.87	157.25	2457.92	121.60	94.69	706.60
0	318.33	2690.66	46.52	4.19	189.10	187.90	2742.10	139.08	116.51	820.63
5	383.03	3075.38	56.93	5.41	225.11	222.90	3055.86	167.20	142.11	949.08
10	457.40	3499.86	61.11	6.92	266.38	262.90	3401.91	193.80	171.95	1089.63
15	543.34	3964.69	83.26	8.76	313.41	307.98	3783.17	226.48	206.49	1244.79
20	638.78	4471.66	99.62	11.00	366.69	358.60	4202.79	258.40	246.20	1415.15
25	747.70	5020.73	118.42	13.69	426.74	415.10	4664.14	297.92	291.60	1601.24
30	870.10	5611.90	139.90	16.91	494.05	477.80	5170.85	338.20	343.18	1803.53
35	1007.02	6244.73	164.32	20.71	569.11	-	6335.98	383.80	401.48	2002.43
40	1159.53	6918.44	191.96	25.17	-	-	-	434.72	467.02	2258.25
45	1328.73	7631.46	223.07	30.38	-	-	-	478.80	540.35	2495.43
50	1515.83	-	257.94	36.40	-	-	-	521.36	622.00	2781.48
55	1721.98	-	266.84	43.32	-	-	-	-	712.50	3069.07
60	1948.21	-	340.05	51.22	-	-	-	-	812.38	3374.02
65	2196.51	-	387.85	-	-	-	-	-	922.14	3696.15
70	2467.55	-	440.50	-	-	-	-	-	-	4035.32
75	2763.00	-	498.27	-	-	-	-	-	-	-
80	3084.31	-	561.41	-	-	-	-	-	-	-
85	3433.09	-	630.16	-	-	-	-	-	-	-
90	3810.92	-	704.75	-	-	-	-	-	-	-
95	4219.57	-	785.39	-	-	-	-	-	-	-
100	4660.82	-	872.28	-	-	-	-	-		-

VAPOR PRESSURE.

TABLE 131. — Vapor Pressure of Ethyl Alcohol.*

Temp. C.	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°
	Vapor pressure in millimetres of mercury at 0° C.									
0°	12.24	13.18	14.15	15.16	16.21	17.31	18.46	19.68	20.98	22.34
10	23.78	25.31	27.94	28.67	30.50	32.44	34.49	36.67	38.97	41.40
20	44.00	46.66	49.47	52.44	55.56	58.86	62.33	65.97	69.80	73.83
30	78.06	82.50	87.17	92.07	97.21	102.60	108.24	114.15	120.35	126.86
40	133.70	140.75	148.10	155.80	163.80	172.20	181.00	190.10	199.65	209.60
50	220.00	230.80	242.50	253.80	265.90	278.60	291.85	305.65	319.95	334.85
60	350.30	366.40	383.10	400.40	418.35	437.00	456.35	476.45	497.25	518.85
70	541.20	564.35	588.35	613.20	638.95	665.55	693.10	721.55	751.00	781.45

From the formula $\log p = a + b\alpha^t + c\beta^t$ Ramsay and Young obtain the following numbers.†

Temp. C.	0°	10°	20°	30°	40°	50°	60°	70°	80°	90°
	Vapor pressure in millimetres of mercury at 0° C.									
0°	12.24	23.73	43.97	78.11	133.42	219.82	350.21	540.91	811.81	1186.5
100	1692.3	2359.8	3223.0	4318.7	5686.6	7368.7	9409.9	11858.	14764.	18185.
200	22182.	26825.	32196.	38389.	45519.					

TABLE 132. — Vapor Pressure of Methyl Alcohol.‡

Temp. C.	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°
	Vapor pressure in millimetres of mercury at 0° C.									
0°	29.97	31.6	33.6	35.6	37.8	40.2	42.6	45.2	47.9	50.8
10	53.8	57.0	60.3	63.8	67.5	71.4	75.5	79.8	84.3	89.0
20	94.0	99.2	104.7	110.4	116.5	122.7	129.3	136.2	143.4	151.0
30	158.9	167.1	175.7	184.7	194.1	203.9	214.1	224.7	235.8	247.4
40	259.4	271.9	285.0	298.5	312.6	327.3	342.5	358.3	374.7	391.7
50	409.4	427.7	446.6	466.3	486.6	507.7	529.5	552.0	575.3	599.4
60	624.3	650.0	676.5	703.8	732.0	761.1	791.1	822.0	–	–

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* This table has been compiled from results published by Ramsay and Young (Jour. Chem. Soc. vol. 47, and Phil. Trans. Roy. Soc., 1886).

† In this formula $a = 5.0720301$; $\log b = \bar{2}.6406131$; $\log c = 0.6050854$; $\log \alpha = 0.003377538$; $\log \beta = \bar{1}.99682424$ (c is negative).

‡ Taken from a paper by Dittmar and Fawsitt (Trans. Roy. Soc. Edin. vol. 33).

TABLE 133.

VAPOR PRESSURE.*

Carbon Disulphide, Chlorobenzene, Bromobenzene, and Aniline.

Temp.	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°
(a) CARBON DISULPHIDE.										
0°	127.90	133.85	140.05	146.45	153.10	160.00	167.15	174.60	182.25	190.20
10	198.45	207.00	215.80	224.95	234.40	244.15	254.25	264.65	275.40	286.55
20	298.05	309.90	322.10	334.70	347.70	361.10	374.95	389.20	403.90	419.00
30	434.60	450.65	467.15	484.15	501.65	519.65	538.15	557.15	576.75	596.85
40	617.50	638.70	660.50	682.90	705.90	729.50	753.75	778.60	804.10	830.25
(b) CHLOROBENZENE.										
20°	8.65	9.14	9.66	10.21	10.79	11.40	12.04	12.71	13.42	14.17
30	14.95	15.77	16.63	17.53	18.47	19.45	20.48	21.56	22.69	23.87
40	25.10	26.38	27.72	29.12	30.58	32.10	33.69	35.35	37.08	38.88
50	40.75	42.69	44.72	46.84	49.05	51.35	53.74	56.22	58.79	61.45
60	64.20	67.06	70.03	73.11	76.30	79.60	83.02	86.56	90.22	94.00
70	97.90	101.95	106.10	110.41	114.85	119.45	124.20	129.10	134.15	139.40
80	144.80	150.30	156.05	161.95	168.00	174.25	181.70	187.30	194.10	201.15
90	208.35	215.80	223.45	231.30	239.35	247.70	256.20	265.00	274.00	283.25
100	292.75	302.50	312.50	322.80	333.35	344.15	355.25	366.65	378.30	390.25
110	402.55	415.10	427.95	441.15	454.65	468.50	482.65	497.20	512.05	527.25
120	542.80	558.70	575.05	591.70	608.75	626.15	643.95	662.15	680.75	699.65
130	718.95	738.65	758.80	–	–	–	–	–	–	–
(c) BROMOBENZENE.										
40°	–	–	–	–	–	12.40	13.06	13.75	14.47	15.22
50	16.00	16.82	17.68	18.58	19.52	20.50	21.52	22.59	23.71	24.88
60	26.10	27.36	28.68	30.06	31.50	33.00	34.56	36.18	37.86	39.60
70	41.40	43.28	45.24	47.28	49.40	51.60	53.88	56.25	58.71	61.26
80	63.90	66.64	69.48	72.42	75.46	78.60	81.84	85.20	88.68	92.28
90	96.00	99.84	103.80	107.88	112.08	116.40	120.86	125.46	130.20	135.08
100	140.10	145.26	150.57	156.03	161.64	167.40	173.32	179.41	185.67	192.10
110	198.70	205.48	212.44	219.58	226.90	234.40	242.10	250.00	258.10	266.40
120	274.90	283.65	292.60	301.75	311.15	320.80	330.70	340.80	351.15	361.80
130	372.65	383.75	395.10	406.70	418.60	430.75	443.20	455.90	468.90	482.20
140	495.80	509.70	523.90	538.40	553.20	568.35	583.85	599.65	615.75	632.25
150	649.05	666.25	683.80	701.65	719.95	738.55	757.55	776.95	796.70	816.90
(d) ANILINE.										
80°	18.80	19.78	20.79	21.83	22.90	24.00	25.14	26.32	27.54	28.80
90	30.10	31.44	32.83	34.27	35.76	37.30	38.90	40.56	42.28	44.06
100	45.90	47.80	49.78	51.84	53.98	56.20	58.50	60.88	63.34	65.88
110	68.50	71.22	74.04	76.96	79.98	83.10	86.32	89.66	93.12	96.70
120	100.40	104.22	108.17	112.25	116.46	120.80	125.28	129.91	134.69	139.62
130	144.70	149.94	155.34	160.90	166.62	172.50	178.56	184.80	191.22	197.82
140	204.60	211.58	218.76	226.14	233.72	241.50	249.50	257.72	266.16	274.82
150	283.70	292.80	302.15	311.75	321.60	331.70	342.05	352.65	363.50	374.60
160	386.00	397.65	409.60	421.80	434.30	447.10	460.20	473.60	487.25	501.25
170	515.60	530.20	545.20	560.45	576.10	592.05	608.35	625.05	642.05	659.45
180	677.15	695.30	713.75	732.65	751.90	771.50	–	–	–	–

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* These tables of vapor pressures are quoted from results published by Ramsay and Young (Jour. Chem. Soc. vol. 47). The tables are intended to give a series suitable for hot-jacket purposes.

VAPOR PRESSURE.

Methyl Salicylate, Bromonaphthaline, and Mercury.

Temp. C.	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°
					(e) METHYL SALICYLATE.					
70°	2.40	2.58	2.77	2.97	3.18	3.40	3.62	3.85	4.09	4.34
80	4.60	4.87	5.15	5.44	5.74	6.05	6.37	6.70	7.05	7.42
90	7.80	8.20	8.62	9.06	9.52	9.95	10.44	10.95	11.48	12.03
100	12.60	13.20	13.82	14.47	15.15	15.85	16.58	17.34	18.13	18.95
110	19.80	20.68	21.60	22.55	23.53	24.55	25.61	26.71	27.85	29.03
120	30.25	31.52	32.84	34.21	35.63	37.10	38.67	40.24	41.84	43.54
130	45.30	47.12	49.01	50.96	52.97	55.05	57.20	59.43	61.73	64.10
140	66.55	69.08	71.69	74.38	77.15	80.00	82.94	85.97	89.09	92.30
150	95.60	99.00	102.50	106.10	109.80	113.60	117.51	121.53	125.66	129.90
160	134.25	138.72	143.31	148.03	152.88	157.85	162.95	168.19	173.56	179.06
170	184.70	190.48	196.41	202.49	208.72	215.10	221.65	228.30	235.15	242.15
180	249.35	256.70	264.20	271.90	279.75	287.80	296.00	304.48	313.05	321.85
190	330.85	340.05	349.45	359.05	368.85	378.90	389.15	399.60	410.30	421.20
200	432.35	443.75	455.35	467.25	479.35	491.70	504.35	517.25	530.40	543.80
210	557.50	571.45	585.70	600.25	615.05	630.15	645.55	661.25	677.25	693.60
220	710.10	727.05	744.35	761.90	779.85	798.10				
					(f) BROMONAPHTHALINE.					
110°	3.60	3.74	3.89	4.05	4.22	4.40	4.59	4.79	5.00	5.22
120	5.45	5.70	5.96	6.23	6.51	6.80	7.10	7.42	7.76	8.12
130	8.50	8.89	9.29	9.71	10.15	10.60	11.07	11.56	12.07	12.60
140	13.15	13.72	14.31	14.92	15.55	16.20	16.87	17.56	18.28	19.03
150	19.80	20.59	21.41	22.25	23.11	24.00	24.92	25.86	26.83	27.83
160	28.85	29.90	30.98	32.09	33.23	34.40	35.60	36.83	38.10	39.41
170	40.75	42.12	43.53	44.99	46.50	48.05	49.64	51.28	52.96	54.68
180	56.45	58.27	60.14	62.04	64.06	66.10	68.19	70.34	72.55	74.82
190	77.15	79.54	81.99	84.51	87.10	89.75	92.47	95.26	98.12	101.05
200	104.05	107.12	110.27	113.50	116.81	120.20	123.67	127.22	130.86	134.59
210	138.40	142.30	146.29	150.38	154.57	158.85	163.25	167.70	172.30	176.95
220	181.75	186.65	191.65	196.75	202.00	207.35	212.80	218.40	224.15	230.00
230	235.95	242.05	248.30	254.65	261.20	267.85	274.65	281.60	288.70	295.95
240	303.35	310.90	318.65	326.50	334.55	342.75	351.10	359.65	368.40	377.30
250	386.35	395.60	405.05	414.65	424.45	434.45	444.65	455.00	465.60	476.35
260	487.35	498.55	509.90	521.50	533.35	545.35	557.60	570.05	582.70	595.60
270	608.75	622.10	635.70	649.50	663.55	677.85	692.40	707.15	722.15	737.45
					(g) MERCURY.					
270°	123.92	126.97	130.08	133.26	136.50	139.81	143.18	146.61	150.12	153.70
280	157.35	161.07	164.86	168.73	172.67	176.79	180.88	185.05	189.30	193.63
290	198.04	202.53	207.10	211.76	216.50	221.33	226.25	231.25	236.34	241.53
300	246.81	252.18	257.65	263.21	268.87	274.63	280.48	286.43	292.49	298.66
310	304.93	311.30	317.78	324.37	331.08	337.89	344.81	351.85	359.00	366.28
320	373.67	381.18	388.81	396.56	404.43	412.44	420.58	428.83	437.22	445.75
330	454.41	463.20	472.12	481.19	490.40	499.74	509.22	518.85	528.63	538.56
340	548.64	558.87	569.25	579.78	590.48	601.33	612.34	623.51	634.85	646.36
350	658.03	669.86	681.86	694.04	706.40	718.94	731.65	744.54	757.61	770.87
360	784.31									

TABLE 134.

VAPOR PRESSURE OF SOLUTIONS OF SALTS IN WATER.*

The first column gives the chemical formula of the salt. The headings of the other columns give the number of gramme-molecules of the salt in a litre of water. The numbers in these columns give the lowering of the vapor pressure produced by the salt at the temperature of boiling water under 76 centimetres barometric pressure.

Substance.	0.5	1.0	2.0	3.0	4.0	5.0	8.0	8.0	10.0
$Al_2(SO_4)_3$	12.8	36.5							
$AlCl_3$	22.5	61.0	179.0	318.0					
$Ba(SO_3)_2$	6.6	15.4	34.4						
$Ba(OH)_2$	12.3	22.5	39.0						
$Ba(NO_3)_2$	13.5	27.0							
$Ba(ClO_3)_2$	15.8	33.3	70.5	108.2					
$BaCl_2$	16.4	36.7	77.6						
$BaBr_2$	16.8	38.8	91.4	150.0	204.7				
$Ca(SO_3)_2$	9.9	23.0	56.0	106.0					
$Ca(NO_3)_2$	16.4	34.8	74.6	139.3	161.7	205.4			
$CaCl_2$	17.0	39.8	95.3	166.6	241.5	319.5			
$CaBr_2$	17.7	44.2	105.8	191.0	283.3	368.5			
$CdSO_4$	4.1	8.9	18.1						
CdI_2	7.6	14.8	33.5	52.7					
$CdBr_2$	8.6	17.8	36.7	55.7	80.0				
$CdCl_2$	9.6	18.8	36.7	57.0	77.3	99.0			
$Cd(NO_3)_2$	15.9	36.1	78.0	122.2					
$Cd(ClO_3)_2$	17.5								
$CoSO_4$	5.5	10.7	22.9	45.5					
$CoCl_2$	15.0	34.8	83.0	136.0	186.4				
$Co(NO_3)_2$	17.3	39.2	89.0	152.0	218.7	282.0	332.0		
$FeSO_4$	5.8	10.7	24.0	42.4					
H_3BO_3	6.0	12.3	25.1	38.0	51.0				
H_3PO_4	6.6	14.0	28.6	45.2	62.0	81.5	103.0	146.9	189.5
H_3AsO_4	7.3	15.0	30.2	46.4	64.9				
H_2SO_4	12.9	26.5	62.8	104.0	148.0	198.4	247.0	343.2	
KH_2PO_4	10.2	19.5	33.3	47.8	60.5	73.1	85.2		
KNO_3	10.3	21.1	40.1	57.6	74.5	88.2	102.1	126.3	148.0
$KClO_3$	10.6	21.6	42.8	62.1	80.0				
$KBrO_3$	10.9	22.4	45.0						
$KHSO_4$	10.9	21.9	43.3	65.3	85.5	107.8	129.2	170.0	
KNO_2	11.1	22.8	44.8	67.0	90.0	110.5	130.7	167.0	198.8
$KClO_4$	11.5	22.3							
KCl	12.2	24.4	48.8	74.1	100.9	128.5	152.2		
$KHCO_2$	11.6	23.6	59.0	77.6	104.2	132.0	160.0	210.0	255.0
KI	12.5	25.3	52.2	82.6	112.2	141.5	171.8	225.5	278.5
$K_2C_2O_4$	13.9	28.3	59.8	94.2	131.0				
K_2WO_4	13.9	33.0	75.0	123.8	175.4	226.4			
K_2CO_3	14.4	31.0	68.3	105.5	152.0	209.0	258.5	350.0	
KOH	15.0	29.5	64.0	99.2	140.0	181.8	223.0	309.5	387.8
K_2CrO_4	16.2	29.5	60.0						
$LiNO_3$	12.2	25.9	55.7	88.9	122.2	155.1	188.0	253.4	309.2
$LiCl$	12.1	25.5	57.1	95.0	132.5	175.5	219.5	311.5	393.5
$LiBr$	12.2	26.2	60.0	97.0	140.0	186.3	241.5	341.5	438.0
Li_2SO_4	13.3	28.1	56.8	89.0					
$LiHSO_4$	12.8	27.0	57.0	93.0	130.0	168.0			
LiI	13.6	28.6	64.7	105.2	154.5	206.0	264.0	357.0	445.0
Li_2SiFl_6	15.4	34.0	70.0	106.0					
$LiOH$	15.9	37.4	78.1						
Li_2CrO_4	16.4	32.6	74.0	120.0	171.0				

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* Compiled from a table by Tammann, "Mém. Ac. St. Petersb." 35, No. 9, 1887. See also Referate, "Zeit. f. Phys." ch. 2, 42, 1886.

TABLE 134 (*continued*).

VAPOR PRESSURE OF SOLUTIONS OF SALTS IN WATER.

Substance.	0.5	1.0	2.0	3.0	4.0	5.0	6.0	8.0	10.0
$MgSO_4$	6.5	12.0	24.5	47.5					
$MgCl_2$	16.8	39.0	100.5	183.3	277.0	377.0			
$Mg(NO_3)_2$	17.6	42.0	101.0	174.8					
$MgBr_2$	17.9	44.0	115.8	205.3	298.5				
$MgH_2(SO_4)_2$	18.3	46.0	116.0						
$MnSO_4$	6.0	10.5	21.0						
$MnCl_2$	15.0	34.0	76.0	122.3	167.0	209.0			
NaH_2PO_4	10.5	20.0	36.5	51.7	66.8	82.0	96.5	126.7	157.1
$NaHSO_4$	10.9	22.1	47.3	75.0	100.2	126.1	148.5	189.7	231.4
$NaNO_3$	10.6	22.5	46.2	68.1	90.3	111.5	131.7	167.8	198.8
$NaClO_3$	10.5	23.0	48.4	73.5	98.5	123.3	147.5	196.5	223.5
$(NaPO_3)_6$	11.6								
$NaOH$	11.8	22.8	48.2	77.3	107.5	139.1	172.5	243.3	314.0
$NaNO_2$	11.6	24.4	50.0	75.0	98.2	122.5	146.5	189.0	226.2
$NaHPO_4$	12.1	23.5	43.0	60.0	78.7	99.8	122.1		
$NaHCO_2$	12.9	24.1	48.2	77.6	102.2	127.8	152.0	198.0	239.4
$NaSO_4$	12.6	25.0	48.9	74.2					
$NaCl$	12.3	25.2	52.1	80.0	111.0	143.0	176.5		
$NaBrO_3$	12.1	25.0	54.1	81.3	108.8	136.0			
$NaBr$	12.6	25.9	57.0	89.2	124.2	159.5	197.5	268.0	
NaI	12.1	25.6	60.2	99.5	136.7	177.5	221.0	301.5	370.0
$Na_4P_2O_7$	13.2	22.0							
Na_2CO_3	14.3	27.3	53.5	80.2	111.0				
$Na_2C_2O_4$	14.5	30.0	65.8	105.8	146.0				
Na_2WO_4	14.8	33.6	71.6	115.7	162.6				
Na_3PO_4	16.5	30.0	52.5						
$(NaPO_3)_3$	17.1	36.5							
NH_4NO_3	12.8	22.0	42.1	62.7	82.9	103.8	121.0	152.2	180.0
$(NH_4)_2SiFl_6$	11.5	25.0	44.5						
NH_4Cl	12.0	23.7	45.1	69.3	94.2	118.5	138.2	179.0	213.8
NH_4HSO_4	11.5	22.0	46.8	71.0	94.5	118.	139.0	181.2	218.0
$(NH_4)_2SO_4$	11.0	24.0	46.5	69.5	93.0	117.0	141.8		
NH_4Br	11.9	23.9	48.8	74.1	99.4	121.5	145.5	190.2	228.5
NH_4I	12.9	25.1	49.8	78.5	104.5	132.3	156.0	200.0	243.5
$NiSO_4$	5.0	10.2	21.5						
$NiCl_2$	16.1	37.0	86.7	147.0	212.8				
$Ni(NO_3)_2$	16.1	37.3	91.3	156.2	235.0				
$Pb(NO_3)_2$	12.3	23.5	45.0	63.0					
$Sr(SO_3)_2$	7.2	20.3	47.0						
$Sr(NO_3)_2$	15.8	31.0	64.0	97.4	131.4				
$SrCl_2$	16.8	38.8	91.4	156.8	223.3	281.5			
$SrBr_2$	17.8	42.0	101.1	179.0	267.0				
$ZnSO_4$	4.9	10.4	21.5	42.1	66.2				
$ZnCl_2$	9.2	18.7	46.2	75.0	107.0	153.0	195.0		
$Zn(NO_3)_2$	16.6	39.0	93.5	157.5	223.8				

TABLE 135.

PRESSURE OF AQUEOUS VAPOR AT LOW TEMPERATURE.*

Pressures are given in inches and millimetres of mercury, temperatures in degrees Fahrenheit and degrees Centigrade.

(a) Pressures in inches of mercury; temperatures in degrees Fahrenheit.

Temp. F.	0°.0	1°.0	2°.0	3°.0	4°.0	5°.0	6°.0	7°.0	8°.0	9°.0
—50°	0.0021	0.0019	0.0018	0.0017	0.0016	0.0015	0.0013	0.0013	0.0012	0.0011
—40	.0039	.0037	.0035	.0033	.0031	.0029	.0027	.0026	.0024	.0022
—30	.0069	.0065	.0061	.0057	.0054	.0051	.0048	.0046	.0044	.0041
—20	.0126	.0119	.0112	.0106	.0100	.0094	.0089	.0083	.0078	.0074
—10	.0222	.0210	.0199	.0188	.0178	.0168	.0159	.0150	.0141	.0133
—0	0.0383	0.0263	0.0244	0.0225	0.0307	0.0291	0.0275	0.0260	0.0247	0.0234
+0	.0383	.0403	.0423	.0444	.0467	.0491	.0515	.0542	.0570	.0600
10	.0631	.0665	.0699	.0735	.0772	.0810	.0850	.0891	.0933	.0979
20	.1026	.1077	.1130	.1185	.1242	.1302	.1365	.1430	.1497	.1568
30	.1641	.1718	.1798							

(b) Pressures in millimetres of mercury; temperatures in degrees Fahrenheit.

Temp. F.	0°.0	1°.0	2°.0	3°.0	4°.0	5°.0	6°.0	7°.0	8°.0	9°.0
—50°	0.053	0.049	0.046	0.043	0.040	0.037	0.034	0.032	0.030	0.028
—40	.100	.094	.089	.084	.079	.074	.069	.065	.061	.057
—30	.176	.165	.155	.146	.138	.130	.123	.117	.111	.105
—20	.319	.301	.284	.268	.253	.239	.225	.212	.199	.187
—10	.564	.534	.505	.478	.452	.427	.403	.384	.358	.338
—0°	0.972	0.922	0.873	0.826	0.781	0.738	0.698	0.661	0.627	0.595
+0	.972	1.023	1.075	1.129	1.186	1.246	1.309	1.376	1.447	1.523
10	1.603	1.688	1.776	1.867	1.961	2.058	2.158	2.262	2.371	2.486
20	2.607	2.735	2.869	3.009	3.155	3.307	3.466	3.631	3.803	3.982
30	4.169	4.364	4.568							

(c) Pressures in inches of mercury; temperatures in degrees Centigrade.

Temp. C.	0°.0	1°.0	2°.0	3°.0	4°.0	5°.0	6°.0	7°.0	8°.0	9°.0
—0°	0.1798	0.1655	0.1524	0.1395	0.1290	0.1185	0.1091	0.0998	0.0916	0.0842
—10	.0772	.0706	.0645	.0588	.0537	.0491	.0449	.0411	.0375	.0341
—20	.0307	.0278	.0252	.0229	.0208	.0188	.0171	.0153	.0138	.0124
—30	.0112	.0101	.0091	.0082	.0073	.0065	.0059	.0053	.0048	.0044
—40	.0040	.0036	.0032	.0029	.0025	.0022	.0020	.0017	.0015	.0013

(d) Pressures in millimetres of mercury; temperatures in degrees Centigrade.

Temp. C.	0°.0	1°.0	2°.0	3°.0	4°.0	5°.0	6°.0	7°.0	8°.0	9°.0
—0°	4.568	4.208	3.875	3.565	3.277	3.009	2.767	2.534	2.327	2.138
—10	1.961	1.794	1.637	1.493	1.363	1.246	1.140	1.044	0.952	0.864
—20	0.781	0.706	0.641	0.583	0.528	0.478	0.432	0.389	0.350	0.315
—30	0.284	0.256	0.231	0.207	0.185	0.165	0.148	0.133	0.121	0.110
—40	0.100	0.090	0.081	0.072	0.064	0.057	0.050	0.044	0.039	0.034

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* Marvin's results (Ann. Rept. U. S. Chief Signal Officer, 1891, App. 10).

TABLE 136.

PRESSURE OF AQUEOUS VAPOR, 0° C TO 100° C.

According to Broch.*

Temp. °C.	0.0	0.2	0.4	0.8	0.8	1.0	1.2	1.4	1.6	1.8
+0	4.57	4.64	4.70	4.77	4.84	4.91	4.98	5.05	5.12	5.20
2	5.27	5.35	5.42	5.50	5.58	5.66	5.74	5.82	5.90	5.99
4	6.07	6.15	6.24	6.33	6.42	6.51	6.60	6.69	6.78	6.88
6	6.97	7.07	7.17	7.26	7.36	7.47	7.57	7.67	7.78	7.88
8	7.99	8.10	8.21	8.32	8.43	8.55	8.66	8.78	8.90	9.02
10	9.14	9.26	9.39	9.51	9.64	9.77	9.90	10.03	10.16	10.30
12	10.43	10.57	10.71	20.85	10.99	11.14	11.28	11.43	11.58	11.73
14	11.88	12.04	12.19	12.35	12.51	12.67	12.84	13.00	13.17	13.34
16	13.51	13.68	13.86	14.04	14.21	14.40	14.58	14.76	14.95	15.14
18	15.33	15.52	15.72	15.92	16.12	16.32	16.52	16.73	16.94	17.15
20	17.36	17.58	17.80	18.02	18.24	18.47	18.69	18.92	19.16	19.39
22	19.63	19.87	20.11	20.36	20.61	20.86	21.11	21.37	21.63	21.89
24	22.15	22.42	22.69	22.96	23.24	23.52	23.80	24.08	24.37	24.66
26	24.96	25.25	25.55	25.86	26.16	26.47	26.78	27.10	27.42	27.74
28	28.07	28.39	28.73	29.06	29.40	29.74	30.09	30.44	30.79	31.15
30	31.51	31.87	32.24	32.61	32.99	33.37	33.75	34.14	34.53	34.92
32	35.32	35.72	36.13	36.54	36.95	37.37	37.79	38.22	38.65	39.08
34	39.52	39.97	40.41	40.87	41.32	41.78	42.25	42.72	43.19	43.67
36	44.16	44.65	45.14	45.64	46.14	46.65	47.16	47.68	48.20	48.73
38	49.26	49.80	50.34	50.89	51.44	52.00	52.56	53.13	53.70	54.28
40	54.87	55.46	56.05	56.65	57.26	57.87	58.49	59.11	59.74	60.38
42	61.02	61.66	62.32	62.98	63.64	64.31	64.99	65.67	66.36	67.05
44	67.76	68.47	69.18	69.90	70.63	71.36	72.10	72.85	73.60	74.36
46	75.13	75.91	76.69	77.47	78.27	79.07	79.88	80.70	81.52	82.35
48	83.19	84.03	84.89	85.75	86.61	87.49	88.37	89.26	90.16	91.06
50	91.98	92.90	93.83	94.77	95.71	96.66	97.63	98.60	99.57	100.56
52	101.55	102.56	103.57	104.59	105.62	106.65	107.70	108.76	109.82	110.89
54	111.97	113.06	114.16	115.27	116.39	117.52	118.65	119.80	120.95	122.12
56	123.29	124.48	125.67	126.87	128.09	129.31	130.54	131.79	133.04	134.30
58	135.58	136.86	138.15	139.46	140.77	142.10	143.43	144.78	146.14	147.51
60	148.88	150.27	151.68	153.09	154.51	155.95	157.39	158.85	160.32	161.80
62	163.29	164.79	166.31	167.83	169.37	170.92	172.49	174.06	175.65	177.25
64	178.86	180.48	182.12	183.77	185.43	187.10	188.79	190.49	192.20	193.93
66	195.67	197.42	199.18	200.96	202.75	204.56	206.38	208.21	210.06	211.92
68	213.79	215.68	217.58	219.50	221.43	223.37	225.33	227.30	229.29	231.29
70	233.31	235.34	237.39	239.45	241.52	243.62	245.72	247.85	249.98	252.14
72	254.30	256.49	258.69	260.91	263.14	265.38	267.65	269.93	272.23	274.54
74	276.87	279.21	281.58	283.95	286.35	288.76	291.19	293.64	296.11	298.59
76	301.09	303.60	306.14	308.69	311.26	313.85	316.45	319.07	321.72	324.38
78	327.05	329.75	332.47	335.20	337.95	340.73	343.52	346.33	349.16	352.01
80	354.87	357.76	360.67	363.59	366.54	369.51	372.49	375.50	378.53	381.58
82	384.64	387.73	390.84	393.97	397.12	400.29	403.49	406.70	409.94	413.19
84	416.47	419.77	423.09	426.44	429.81	433.19	436.60	440.04	443.49	446.97
86	450.47	454.00	457.54	461.11	464.71	468.32	471.96	475.63	479.32	483.03
88	486.76	490.52	494.31	498.12	501.95	505.81	509.69	513.60	517.53	521.48
90	525.47	529.48	533.51	537.57	541.65	545.77	549.90	554.07	558.26	562.47
92	566.71	570.98	575.28	579.61	583.96	588.33	592.74	597.17	601.64	606.13
94	610.64	615.19	619.76	624.37	629.00	633.66	638.35	643.06	647.81	652.59
96	657.40	662.23	667.10	672.00	676.92	681.88	686.87	691.89	696.93	702.02
98	707.13	712.27	717.44	722.65	727.89	733.16	738.46	743.80	749.17	754.57
100	760.00	765.47	770.97	776.50	782.07	787.67	-	-	-	-

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* This table is based on Regnault's experiments, the numbers being taken from Broch's reduction of the observations (Trav. et Mém. du Bur. Int. des Poids et Més. tom. 1).

TABLE 137.

PRESSURE OF AQUEOUS VAPOR, 100° C. TO 230° C.

According to Regnault.

Temp. ° Cent.	Pressure: mm. of mercury.	Grammes per sq. centimetre.	Pounds per sq. inch.	Pressure: inches of mercury.	Pressure: atmospheres.	Temp. ° Fahr.	Temp. ° Cent.	Pressure: mm. of mercury.	Grammes per sq. centimetre.	Pounds per sq. inch.	Pressure: inches of mercury.	Pressure: atmospheres.	Temp. ° Fahr.
100	760.00	1033.26	14.70	29.92	1.000	**212.0**	**150**	3581.2	4868.9	69.26	141.0	4.712	**302.0**
101	787.59	1070.78	15.23	31.01	.036	213.8	151	3678.4	5001.1	71.14	144.8	.840	303.8
102	816.01	1109.41	15.79	32.13	.074	215.6	152	3777.7	5136.1	73.06	148.7	.971	305.6
103	845.28	1149.21	16.35	33.28	.112	217.4	153	3879.2	5275.0	75.02	152.7	5.104	307.4
104	875.41	1190.17	16.94	34.46	.152	219.2	154	3982.8	5414.8	77.03	156.8	.240	309.2
105	906.41	1232.32	17.53	35.69	1.193	**221.0**	**155**	4088.6	5558.6	79.07	161.0	5.380	**311.0**
106	938.31	1275.69	18.15	36.94	.235	222.8	156	4196.6	5705.5	81.22	165.2	.522	312.8
107	971.14	1320.32	18.78	38.23	.278	224.6	157	4306.9	5855.5	83.29	169.6	.667	314.6
108	1004.91	1366.24	19.44	39.56	.322	226.4	158	4419.5	6008.5	85.47	174.0	.815	316.4
109	1039.65	1413.47	20.11	40.93	368	228.2	159	4534.4	6164.7	87.69	178.5	.966	318.2
110	1075.37	1462.03	20.80	42.34	1.415	**230.0**	**160**	4651.6	6324.2	89.96	183.1	6.120	**320.0**
111	1112.09	1511.97	21.51	43.78	.463	231.8	161	4771.3	6486.8	92.27	187.9	.278	321.8
112	1149.83	1563.26	22.24	45.25	.513	233.6	162	4893.4	6652.8	94.63	192.7	.439	323.6
113	1188.61	1615.99	22.99	46.80	.564	235.4	163	5017.9	6822.2	97.04	197.6	.603	325.4
114	1228.47	1670.18	23.76	48.37	.616	237.2	164	5145.0	6994.9	99.50	202.6	.770	327.2
115	1269.41	1725.84	24.55	49.98	1.670	**239.0**	**165**	5274.5	7171.1	102.01	207.7	6.940	**329.0**
116	1311.47	1783.02	25.37	51.63	.726	240.8	166	5406.7	7350.7	104.56	212.9	7.114	330.8
117	1354.66	1841.74	26.20	53.34	.782	242.6	167	5541.4	7533.9	107.18	218.2	.291	332.6
118	1399.02	1902.05	27.06	55.08	.841	244.4	168	5678.8	7720.7	109.84	223.6	.472	334.4
119	1444.55	1963.95	27.94	56.87	.901	246.2	169	5818.9	7911.1	112.53	229.1	.656	336.2
120	1491.28	2027.48	28.85	58.71	1.962	**248.0**	**170**	5961.7	8105.2	115.29	234.1	7.844	**338.0**
121	1539.25	2092.70	29.78	60.61	2.025	249.8	171	6107.2	8303.1	118.11	240.4	8.036	339.8
122	1588.47	2159.62	30.73	62.54	.091	251.6	172	6255.5	8504.7	120.98	246.3	.231	341.6
123	1638.96	2228.26	31.70	64.53	.157	253.4	173	6406.6	8710.2	123.90	252.2	.430	343.4
124	1690.76	2298.69	32.70	66.56	.225	255.2	174	6560.6	8919.5	126.87	258.3	.632	345.2
125	1743.88	2370.91	33.72	68.66	2.295	**257.0**	**175**	6717.4	9132.8	129.91	264.5	8.839	**347.0**
126	1798.35	2444.96	34.78	70.80	.366	258.8	176	6877.2	9350.0	133.00	270.8	9.049	348.8
127	1854.20	2520.89	35.86	73.00	.430	260.6	177	7040.0	9571.3	136.15	277.2	.263	350.6
128	1911.47	2598.76	36.97	75.25	.515	262.4	178	7205.7	9796.6	139.35	283.7	.481	352.4
129	1970.15	2678.54	38.11	77.57	.592	264.2	179	7374.5	10026.1	142.62	290.3	.703	354.2
130	2030.28	2760.29	39.26	79.93	2.671	**266.0**	**180**	7546.4	10259.7	145.93	297.1	9.929	**356.0**
131	2091.94	2844.12	40.47	82.36	.753	267.8	181	7721.4	10497.7	149.32	304.0	10.150	357.8
132	2155.03	2929.89	41.68	84.84	.836	269.6	182	7899.5	10739.9	152.77	311.0	.394	359.6
133	2219.69	3017.80	42.93	87.39	.921	271.4	183	8080.8	10986.4	156.32	318.1	.633	361.4
134	2285.92	3107.85	44.21	89.99	3.008	273.2	184	8265.4	11237.3	159.84	325.4	.876	363.2
135	2353.73	3200.04	45.52	92.67	3.097	**275.0**	**185**	8453.2	11490.0	163.47	332.3	11.123	**365.0**
136	2423.16	3294.43	46.87	95.39	.188	276.8	186	8644.4	11752.5	167.17	340.3	.374	366.8
137	2494.23	3391.06	48.24	98.19	.282	278.6	187	8838.8	12016.9	170.94	348.0	.630	368.6
138	2567.00	3489.99	49.65	101.06	.378	280.4	188	9036.7	12285.9	174.76	355.8	.885	370.4
139	2641.44	3591.29	51.06	103.99	.476	282.2	189	9238.0	12559.6	178.65	363.7	12.155	372.2
140	2717.63	3694.78	52.55	106.99	3.576	**284.0**	**190**	9442.7	12837.9	182.61	371.8	12.425	**374.0**
141	2795.57	3800.75	54.07	110.06	.678	285.8	191	9650.9	13121.0	186.63	380.0	12.699	375.8
142	2875.30	3909.14	55.60	113.20	.783	287.6	192	9862.7	13408.9	190.72	388.3	12.977	377.6
143	2956.86	4020.03	57.16	116.41	.890	289.4	193	10078.0	13701.7	194.88	396.8	13.261	379.4
144	3040.26	4133.42	58.79	119.69	4.000	291.2	194	10297.0	13999.4	199.13	405.4	13.549	381.2
145	3125.55	4249.37	60.44	123.05	4.113	**293.0**	**195**	10519.6	14302.7	203.43	414.1	13.842	**383.0**
146	3212.74	4367.91	62.13	126.48	.227	294.8	196	10746.0	14609.8	207.81	423.1	14.139	384.8
147	3301.87	4489.09	63.86	129.99	.344	296.6	197	10975.0	14921.2	212.25	432.1	14.441	386.6
148	3392.98	4612.96	65.62	133.58	.464	298.4	198	11209.8	15240.4	216.77	441.3	14.749	388.4
149	3486.09	4739.55	67.41	137.25	.587	300.2	199	11447.5	15563.5	221.37	450.7	15.062	390.2

PRESSURE AND WEIGHT OF AQUEOUS VAPOR.

TABLE 137 (*continued*). — Pressure of Aqueous Vapor, 100° C–230° C.

According to Regnault.

Temp. ° Cent.	Pressure: mm. of mercury.	Grammes per sq. centimetre.	Pounds per sq. inch.	Pressure: inches of mercury.	Pressure: atmospheres.	Temp. ° Fahr.	Temp. ° Cent.	Pressure: mm. of mercury.	Grammes per sq. centimetre.	Pounds per sq. inch.	Pressure: inches of mercury.	Pressure: atmospheres.	Temp. ° Fahr.
200	11689.0	15891.9	226.04	460.1	15.380	**392.0**	**215**	15801.3	21482.8	305.57	622.1	20.791	**419.0**
201	11934.4	16225.5	230.79	469.8	15.703	393.8	216	16109.9	21902.4	311.57	634.2	21.197	420.8
202	12183.7	16564.7	235.61	479.7	16.031	395.6	217	16423.2	22328.3	317.62	646.6	21.690	422.6
203	12437.0	16908.8	240.54	489.6	16.364	397.4	218	16740.9	22760.3	323.78	659.1	22.027	424.4
204	12694.3	17257.3	245.49	499.8	16.703	399.2	219	17063.3	23198.6	330.01	671.8	22.452	426.2
205	12955.7	17614.0	250.53	510.1	17.047	**401.0**	**220**	17390.4	23643.2	336.30	684.7	22.882	**428.0**
206	13221.1	17974.9	255.67	520.5	17.396	402.8	221	17722.1	24094.3	342.70	697.7	23.319	429.8
207	13490.8	18341.5	260.88	531.2	17.751	404.6	222	18058.6	24551.8	349.21	711.0	23.761	431.6
208	13764.5	18713.7	266.18	541.9	18.111	406.4	223	18399.9	25015.8	355.81	724.4	24.210	433.4
209	14042.5	19091.6	271.55	552.9	18.477	408.2	224	18746.1	25486.4	362.50	738.0	24.666	435.2
210	14324.8	19475.4	277.01	564.1	18.848	**410.0**	**225**	19097.0	25963.5	369.29	751.9	25.128	**437.0**
211	14611.3	19864.9	282.58	575.3	19.226	411.8	226	19452.9	26447.4	376.17	765.8	25.596	438.8
212	14902.2	20260.5	288.21	586.7	19.608	413.6	227	19813.8	26938.0	383.15	780.9	26.071	440.6
213	15197.5	20661.9	293.92	598.3	19.997	415.4	228	20179.6	27435.4	390.22	794.5	26.552	442.4
214	15497.2	21069.3	299.72	610.2	20.391	417.2	229	20550.5	27939.6	397.40	809.0	27.040	444.2

TABLE 138. — Weight in Grains of the Aqueous Vapor contained in a Cubic Foot of Saturated Air.*

Temp. ° F.	0.0	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0
—10	0.285	0.270	0.257	0.243	0.231	0.218	0.207	0.196	0.184	0.174
—0	0.481	0.457	0.434	0.411	0.389	0.370	0.350	0.332	0.316	0.300
+0	0.481	0.505	0.529	0.554	0.582	0.610	0.639	0.671	0.704	0.739
10	0.776	0.816	0.856	0.898	0.941	0.985	1.032	1.079	1.128	1.181
20	1.235	1.294	1.355	1.418	1.483	1.551	1.623	1.697	1.773	1.853
30	1.935	2.022	2.113	2.194	2.279	2.366	2.457	2.550	2.646	2.746
40	2.849	2.955	3.064	3.177	3.294	3.414	3.539	3.667	3.800	3.936
50	4.076	4.222	4.372	4.526	4.685	4.849	5.018	5.191	5.370	5.555
60	5.745	5.941	6.142	6.349	6.563	6.782	7.009	7.241	7.480	7.726
70	7.980	8.240	8.508	8.782	9.066	9.356	9.655	9.962	10.277	10.601
80	10.934	11.275	11.626	11.987	12.356	12.736	13.127	13.526	13.937	14.359
90	14.790	15.234	15.689	16.155	16.634	17.124	17.626	18.142	18.671	19.212
100	19.766	20.335	20.917	21.514	22.125	22.750	23.392	24.048	24.720	25.408
110	26.112	26.832	27.570	28.325	29.096	29.887	–	–	–	–

* See "Smithsonian Meteorological Tables," pp 132–133.

TABLE 139. — Weight in Grammes of the Aqueous Vapor contained in a Cubic Metre of Saturated Air.

Temp. ° C.	0.0	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0
—20	0.892	0.810	0.737	0.673	0.613	0.557	0.505	0.457	0.413	0.373
—10	2.154	1.978	1.811	1.658	1.519	1.395	1.282	1.177	1.079	0.982
—0	4.835	4.468	4.130	3.813	3.518	3.244	2.988	2.752	2.537	2.340
+0	4.835	5.176	5.538	5.922	6.330	6.761	7.219	7.703	8.215	8.757
10	9.330	9.935	10.574	11.249	11.961	12.712	13.505	14.339	15.218	16.144
20	17.118	18.143	19.222	20.355	21.546	22.796	24.109	25.487	26.933	28.450
30	30.039	31.704	33.449	35.275	37.187	39.187	41.279	43.465	45.751	48.138

TABLE 140.

PRESSURE OF AQUEOUS VAPOR IN THE ATMOSPHERE.

This table gives the vapor pressure corresponding to various values of the difference $t-t_1$ between the readings of dry and wet bulb thermometers and the temperature t_1 of the wet bulb thermometer. The differences $t-t_1$ are given by two-degree steps in the top line, and t_1 by degrees in the first column. Temperatures in Centigrade degrees and Regnault's vapor pressures in millimetres of mercury are used throughout the table. The table was calculated for barometric pressure B equal to 76 centimetres, and a correction is given for each centimetre at the top of the columns.*

t_1	$t-t_1 = 0$	2	4	6	8	10	12	14	16	18	20	Difference per $\frac{1}{10}$° of $t-t_1$
Corrections for B per centimetre.†		.013	.026	.040	.053	.066	.079	.092	.106	.119	.132	
—10	1.96	0.96										0.100
—9	2.14	1.14	0.14									0.100
—8	2.33	1.33	0.33									0.100
—7	2.53	1.53	0.53									0.100
—6	2.76	1.76	0.76									0.100
—5	3.01	2.01	1.00									0.100
—4	3.28	2.28	1.27	0.27								0.100
—3	3.57	2.57	1.56	0.56								0.100
—2	3.88	2.88	1.87	0.87								0.100
—1	4.22	3.22	2.21	1.21	0.21							0.100
0	4.60	3.60	2.59	1.59	0.59							0.100
1	4.94	3.93	2.92	1.92	0.92							0.100
2	5.30	4.29	3.29	2.28	1.28	0.27						0.100
3	5.69	4.68	3.68	2.67	1.66	0.66						0.101
4	6.10	5.09	4.09	3.08	2.07	1.06	0.05					0.101
5	6.53	5.52	4.51	3.50	2.49	1.48	0.48					0.101
6	7.00	5.99	4.98	3.97	2.96	1.95	0.94					0.101
7	7.49	6.48	5.47	4.45	3.44	2.43	1.42	0.41				0.101
8	8.02	7.01	5.99	4.98	3.97	2.96	1.94	0.93				0.101
9	8.57	7.56	6.54	5.53	4.51	3.50	2.49	1.48	0.46			0.101
10	9.17	8.16	7.14	6.12	5.11	4.09	3.08	2.07	1.06	0.05		0.101
11	9.79	8.77	7.76	6.74	5.73	4.71	3.69	2.68	1.66	0.64		0.102
12	10.46	9.44	8.43	7.41	6.39	5.37	4.36	3.34	2.32	1.30	0.28	0.102
13	11.16	10.14	9.12	8.10	7.09	6.07	5.05	4.03	3.01	1.99	0.97	0.102
14	11.91	10.89	9.87	8.85	7.83	6.81	5.79	4.77	3.71	2.69	1.67	0.102
15	12.70	11.68	10.66	9.64	8.62	7.60	6.58	5.56	4.54	3.52	2.50	0.102
16	13.54	12.52	11.50	10.47	9.45	8.43	7.41	6.39	5.37	4.35	3.33	0.102
17	14.42	13.40	12.37	11.35	10.33	9.31	8.28	7.26	6.24	5.22	4.20	0.102
18	15.36	14.34	13.31	12.29	11.26	10.24	9.21	8.19	7.17	6.15	5.13	0.102
19	16.35	15.33	14.30	13.27	12.25	11.22	10.20	9.17	8.15	7.13	6.11	0.102
20	17.39	16.37	15.34	14.31	13.28	12.26	11.23	10.21	9.18	8.15	7.12	0.103
21	18.50	17.47	16.45	15.42	14.39	13.36	12.33	11.31	10.28	9.25	8.22	0.103
22	19.66	18.63	17.60	16.57	15.54	14.51	13.48	12.46	11.43	10.40	9.37	0.103
23	20.89	19.86	18.83	17.80	16.77	15.74	14.71	13.68	12.66	11.63	10.60	0.103
24	22.18	21.15	20.12	19.09	18.05	17.02	15.99	14.96	13.94	12.91	11.88	0.103
25	23.55	22.52	21.49	20.45	19.43	18.39	17.36	16.33	15.30	14.27	13.24	0.103
26	24.99	23.96	22.92	21.89	20.86	19.82	18.79	17.76	16.73	15.70	14.67	0.103
27	26.51	25.48	24.44	23.40	22.37	21.34	20.30	19.27	18.24	17.21	16.18	0.103
28	28.10	27.07	26.03	24.99	23.96	22.92	21.89	20.85	19.82	18.79	17.76	0.103
29	29.78	28.75	27.71	26.67	25.63	24.59	23.56	22.52	21.49	20.46	19.43	0.103
30	31.55	30.51	29.47	28.43	27.40	26.36	25.32	24.29	23.25	22.22	21.18	0.104
31	33.41	32.37	31.33	30.29	29.25	28.22	27.18	26.14	25.10	24.07	23.03	0.104
32	35.36	34.32	33.28	32.24	31.21	30.17	29.13	28.09	27.05	26.01	24.97	0.104
33	37.41	36.37	35.33	34.29	33.25	32.22	31.18	30.14	29.10	28.06	27.02	0.104
34	39.57	38.53	37.48	36.44	35.40	34.36	33.32	32.28	31.24	30.20	29.16	0.104
35	41.83	40.79	39.74	38.70	37.66	36.62	35.68	34.64	33.60	32.56	31.52	0.104
36	44.20	43.16	42.11	41.07	40.03	38.99	37.95	36.90	35.86	34.82	33.78	0.104
37	46.69	45.65	44.60	43.56	42.52	41.48	40.44	39.39	38.35	37.31	36.27	0.104
38	49.30	48.26	47.21	46.17	45.13	44.08	43.04	41.99	40.95	39.91	38.87	0.104
39	52.04	51.00	49.95	48.91	47.86	46.82	45.77	44.73	43.78	42.74	41.69	0.105

Example.

$t-t_1 = 7.2$
$t_1 = 10.0$
$B = 74.5$
Tabular number $= 6.12 - 6 \times .101 = 5.51$
Correction for $B = 1.5 \times .048 \ldots = .07$
Hence we get $p \ldots = 5.58$

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* The table was calculated from the formula $p = p_1 - 0.00066\,B\,(t-t_1)\,(1 + 0.00115\,t_1)$ (Ferrel, Annual Report U. S. Chief Signal Officer, 1886, App. 24).

† When B is less than 76 the correction is to be added, and when B is greater than 76 it is to be subtracted.

TABLE 141.

DEW-

The first column of this table gives the temperatures of the wet-bulb thermometer, and the top line the difference the table. The dew-points were computed for a barometric pressure of 76 centimetres. When the barometer differs and the resulting number added to or subtracted from the tabular number according as the barometer is below or

t_1	$t-t_1=1$	2	3	4	5	6	7	8
	Dew-points corresponding to the difference of temperature given in the above line and the wet-bulb thermometer reading given in first column.							
$\delta T/\delta B=$	.04	.11	.22	.49				
−10	−13.2	−17.9						
−9	12.0	16.0	−22.0					
−8	10.7	14.3	19.4					
−7	9.5	12.7	17.1	−24.0				
−6	8.3	11.2	14.9	20.3				
$\delta T/\delta B=$	.03	.06	.11	.18	.31	.43		
−5	−7.1	−9.7	−12.9	−17.5	−24.5			
−4	6.0	8.3	11.1	14.8	20.1			
−3	4.8	6.9	9.4	12.6	16.8	−23.4		
−2	3.6	5.5	7.8	10.5	13.9	18.9		
−1	2.5	4.2	6.2	8.5	11.5	15.4	−21.0	
$\delta T/\delta B=$	.02	.04	.07	.10	.14	.19	.26	.38
0	−1.3	−2.9	−4.8	−6.8	−9.3	−12.3	−16.5	−22.9
1	0.3	1.7	3.5	5.3	7.6	10.2	13.5	18.3
2	+0.6	0.7	2.2	3.9	6.1	8.3	11.1	14.7
3	1.7	+0.2	1.0	2.6	4.6	6.4	8.9	11.9
4	2.8	1.4	0.0	1.3	3.1	4.7	6.9	9.4
$\delta T/\delta B=$	.02	.03	.05	.07	.09	.11	.14	.18
5	3.8	2.6	+1.2	−0.1	−1.6	−3.2	−5.0	−7.1
6	4.9	3.7	2.5	+1.1	0.2	1.7	3.3	5.2
7	6.0	4.9	3.7	2.4	+1.1	0.3	1.8	3.4
8	7.0	6.0	4.9	3.7	2.5	+1.1	0.3	1.8
9	8.1	7.1	6.1	5.0	3.9	2.6	+1.2	0.1
$\delta T/\delta B=$	.01	.02	.03	.05	.06	.08	.10	.12
10	9.1	8.3	7.3	6.3	5.2	4.1	2.8	+1.5
11	10.2	9.3	8.4	7.5	6.5	5.5	4.3	3.1
12	11.2	10.4	9.6	8.7	7.8	6.8	5.8	4.7
13	12.3	11.5	10.7	9.9	9.1	8.2	7.2	6.2
14	13.3	12.6	11.9	11.1	10.3	9.05	8.6	7.6
$\delta T/\delta B=$	.01	.02	.03	.04	.05	.06	.07	.08
15	14.4	13.7	13.0	12.3	11.5	10.8	9.9	9.1
16	15.4	14.8	14.1	13.5	12.7	12.0	11.3	10.5
17	16.4	15.8	15.2	14.6	13.9	13.3	12.6	11.8
18	17.5	16.9	16.3	15.7	15.1	14.5	13.8	13.1
19	18.5	18.0	17.4	16.9	16.3	15.7	15.1	14.4
$\delta T/\delta B=$	.005	.01	.015	.02	.027	.033	.04	.05
20	19.5	19.0	18.5	18.0	17.4	16.9	16.3	15.7
21	20.5	20.1	19.6	19.1	18.6	18.1	17.5	17.0
22	21.6	21.1	20.7	20.2	19.7	19.2	18.7	18.2
23	22.6	22.2	21.7	21.3	20.8	20.4	19.9	19.4
24	23.6	23.2	22.8	22.4	22.0	21.5	21.1	20.6
$\delta T/\delta B=$	.005	.01	.015	.02	.025	.03	.035	.04
25	24.6	24.2	23.9	23.5	23.1	22.7	22.2	21.8
26	25.6	25.3	24.9	24.5	24.2	23.8	23.4	23.0
27	26.7	26.3	26.0	25.6	25.3	24.9	24.5	24.1
28	27.7	27.3	27.0	26.7	26.4	26.0	25.7	25.3
29	28.7	28.4	28.1	27.8	27.4	27.1	26.8	26.4
$\delta T/\delta B=$	.003	.006	.01	.013	.017	.019	.022	.026
30	29.7	29.4	29.1	28.8	28.5	28.2	27.9	27.6
31	30.7	30.5	30.2	29.9	29.6	29.3	29.0	28.7
32	31.7	31.5	31.2	30.9	30.7	30.4	30.1	29.8
33	32.8	32.5	32.2	32.0	31.7	31.5	31.2	30.9
34	33.8	33.5	33.3	33.0	32.8	32.5	32.3	32.0
$\delta T/\delta B=$	.003	.005	.008	.010	.013	.016	.019	.021
35	34.8	34.5	34.3	34.1	33.8	33.6	33.4	33.1
36	35.8	35.5	35.3	35.1	34.9	34.6	34.4	34.2
37	36.8	36.6	36.4	36.2	36.0	35.7	35.5	35.3
38	37.8	37.6	37.4	37.2	37.0	36.8	36.6	36.4
39	38.8	38.6	38.4	38.2	38.0	37.9	37.6	37.5

between the dry and the wet bulb, when the dew-point has the values given at corresponding points in the body of
from 76 centimetres the corresponding numbers in the lines marked $\delta T/\delta B$ are to be multiplied by the difference,
or above 76. See examples.

Dew-points corresponding to the difference of temperature given in the above line and the wet-bulb thermometer reading given in first column.

EXAMPLES.

(1) Given $B=72$, $t_1=10$, $t-t_1=5$.
Then tabular number for $t_1=10$ and $t-t_1=5$ is 5.2
Also $76-72=4$ and $\delta T/\delta B=.06$.
∴ Correction $=0.06 \times 4=$ 24
Hence the dew-point is 5.44
(2) Given $B=71.5$, $t_1=7$, $t-t_1=8$.
Then, as above, tabulated number $=$ . . . 3.4
$\delta T/\delta B=\frac{.18+.12}{2}=.15$
Correction $=0.15 \times 4.5=$ 67
Dew-point $=$ 4.07

t_1	$t-t_1=9$	10	11	12	13	14	15
$\delta T/\delta B=$	.45	.67					
0							
1							
2	— 20.0						
3	15.8	— 22.2					
4	12.4	16.8					
$\delta T/\delta B=$	.23	.29	.37	.44	.54	.66	.72
5	— 19.8	— 13.1	— 17.7				
6	7.4	10.1	13.4	— 18.1			
7	5.3	7.6	10.1	13.5	— 18.3		
8	3.3	5.2	7.4	10.1	13.5	— 18.3	
9	1.6	3.2	5.1	7.2	9.9	13.1	— 17.2
$\delta T/\delta B=$	.14	.17	.20	.22	.25	.29	.36
10	0.0	— 1.3	— 3.0	— 4.7	— 6.8	— 9.4	— 12.5
11	+ 1.8	+ 0.3	1.0	2.6	4.3	6.3	8.8
12	3.5	2.2	+ 0.8	0.6	2.1	3.7	5.7
13	5.1	3.9	2.7	+ 1.3	0.1	1.6	3.1
14	6.7	5.6	4.5	3.3	+ 1.9	+ 0.5	0.9
$\delta T/\delta B=$	.09	.11	.12	.14	.16	.18	.20
15	8.2	7.2	6.2	5.1	3.9	2.7	+ 1.3
16	9.6	8.7	7.8	6.8	5.8	4.7	3.5
17	11.0	10.2	9.4	8.5	7.5	6.5	5.5
18	12.4	11.7	10.9	10.1	9.2	8.3	7.4
19	13.8	13.1	12.4	11.6	10.8	10.0	9.1
$\delta T/\delta B=$	.06	.07	.08	.09	.10	.11	.13
20	15.1	14.5	13.8	13.1	12.4	11.6	10 8
21	16.4	15.8	15.2	14.5	13.9	13.2	12.5
22	17.6	17.1	16.5	15.9	15.3	14.7	14.0
23	18.9	18.4	17.9	17.3	16.8	16.2	15.7
24	20.1	19.6	19.2	18.7	18.1	17.6	17.0
$\delta T/\delta B=$	.045	.05	.06	.06	.07	.08	.09
25	21.4	20.9	20.4	20.0	19.5	19.0	18.5
26	22.6	22.1	21.7	21.3	20.8	20.3	19.9
27	23.7	23.4	22.9	22.5	22.1	21.7	21.2
28	24.9	24.5	24.2	23.8	23.4	23.0	22.6
29	26.1	25.7	25.4	25.0	24.6	24.2	23.9
$\delta T/\delta B=$	.031	.035	.041	.047	.053	.06	.07
30	27.2	26.9	26.6	26.2	25.9	25.5	25.2
31	28.4	28.1	27.8	27.4	27.1	26.8	26.4
32	29.5	29.2	28.9	28.6	28.3	28.0	27.7
33	30.7	30.4	30.1	29.8	29.5	29.2	28.9
34	31.8	31.5	31.2	30.9	30.7	30.4	30.1
$\delta T/\delta B=$	.024	.027	.029	.032	.037	.037	.04
35	32.9	32.6	32.4	32.1	31.8	31.6	31.4
36	34.0	33.7	33.5	33.3	33.0	32.8	32.5
37	35.1	34.9	34.6	34.4	34.2	33.9	33.7
38	36.2	35.9	35.7	35.5	35.3	35.1	34.8
39	37.3	37.1	36.8	36.6	36.4	36.2	36.0

RELATIVE HUMIDITY.*

This table gives the humidity of the air, for temperature *t* and dew-point *d* in Centigrade degrees, expressed in percentages of the saturation value for the temperature *t*.

Depression of the dew-point. *t*—*d*	Dew-point (*d*).					Depression of the dew-point. *t*—*d*	Dew-point (*d*).				
	—10	0	+10	+20	+30		—10	0	+10	+20	+30
C.						C.					
0°.0	100	100	100	100	100	**8°.0**	54	57	60	62	64
0.2	98	99	99	99	99	8.2	54	56	59	61	63
0.4	97	97	97	98	98	8.4	53	56	58	60	63
0.6	95	96	96	96	97	8.6	52	55	57	60	62
0.8	94	94	95	95	96	8.8	51	54	57	59	61
1.0	92	93	94	94	94	**9.0**	51	53	56	58	61
1.2	91	92	92	93	93	9.2	50	53	55	58	60
1.4	90	90	91	92	92	9.4	49	52	55	57	59
1.6	88	89	90	91	91	9.6	48	51	54	56	59
1.8	87	88	89	90	90	9.8	48	51	53	56	58
2.0	86	87	88	88	89	**10.0**	47	50	53	55	57
2.2	84	85	86	87	88	10.5	45	48	51	54	
2.4	83	84	85	86	87	11.0	44	47	49	52	
2.6	82	83	84	85	86	11.5	42	45	48	51	
2.8	80	82	83	84	85	12.0	41	44	47	49	
3.0	79	81	82	83	84	**12.0**	39	42	45	48	
3.2	78	80	81	82	83	13.0	38	41	44	46	
3.4	77	79	80	81	82	13.5	37	40	43	45	
3.6	76	77	79	80	82	14.0	35	38	41	44	
3.8	75	76	78	79	81	14.5	34	37	40	43	
4.0	73	75	77	78	80	**15.0**	33	36	39	42	
4.2	72	74	76	77	79	15.5	32	35	38	40	
4.4	71	73	75	77	78	16.0	31	34	37	39	
4.6	70	72	74	76	77	16.5	30	33	36	38	
4.8	69	71	73	75	76	17.0	29	32	35	37	
5.0	68	70	72	74	75	**17.5**	28	31	34	36	
5.2	67	69	71	73	75	18.0	27	30	33	35	
5.4	66	68	70	72	74	18.5	26	29	32	34	
5.6	65	67	69	71	73	19.0	25	28	31	33	
5.8	64	66	69	70	72	19.5	24	27	30	33	
6.0	63	66	68	70	71	**20.0**	24	26	29	32	
6.2	62	65	67	69	71	21.0	22	25	27		
6.4	61	64	66	68	70	22.0	21	23	26		
6.6	60	63	65	67	69	23.0	19	22	24		
6.8	60	62	64	66	68	24.0	18	21	23		
7.0	59	61	63	66	68	**25.0**	17	19	22		
7.2	58	60	63	65	67	26.0	16	18	21		
7.4	57	60	62	64	66	27.0	15	17	20		
7.6	56	59	61	63	65	28.0	14	16	19		
7.8	55	58	60	63	65	29.0	13	15	18		
8.0	54	57	60	62	64	**30.0**	12	14	17		

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* Abridged from Table 45 of "Smithsonian Meteorological Tables."

TABLE 143.

VALUES OF 0.378*e*.*

This table gives the humidity term 0.378*e*, which occurs in the equation $\delta = \delta_0 \frac{h}{760} = \delta_0 \frac{B - 0.378e}{760}$ for the calculation of the density of the dry air in a sample containing aqueous vapor at pressure e; δ_0 is the density at normal barometric pressure, B the observed barometric pressure, and h the pressure corrected for humidity. For values of $\frac{h}{760}$ see Table 144. Temperatures are in degrees Centigrade, and pressures in millimetres of mercury.

Dew Point. °C.	*e* Vapor Pressure (ice).	0.378*e*.	Dew Point. °C.	*e* Vapor Pressure (water).	0.378*e*.	Dew Point. °C.	*e* Vapor Pressure (water).	0.378*e*.
—50	0.034	0.01	0	4.579	1.73	+30	31.555	11.93
45	.061	.02	+1	4.921	1.86	31	33.416	12.63
40	.105	.04	2	5.286	2.00	32	35.372	13.37
35	.173	.07	3	5.675	2.15	33	37.427	14.15
30	.292	.11	4	6.088	2.30	34	39.586	14.96
—25	0.484	0.18	5	6.528	2.47	35	41.853	15.82
24	.534	.20	6	6.997	2.65	36	44.23	16.72
23	.589	.22	7	7.494	2.83	37	46.73	17.66
22	.648	.24	8	8.023	3.03	38	49.35	18.65
21	.714	.27	9	8.584	3.24	39	52.09	19.69
—20	0.787	0.30	10	9.179	3.47	40	54.97	20.78
19	.868	.33	11	9.810	3.71	41	57.98	21.92
18	.955	.36	12	10.479	3.96	42	61.13	23.12
17	1.048	.40	13	11.187	4.23	43	64.43	24.35
16	1.148	.44	14	11.936	4.51	44	67.89	25.66
—15	1.257	0.48	15	12.728	4.81	45	71.50	27.02
14	1.375	.52	16	13.565	5.13	46	75.28	28.46
13	1.506	.57	17	14.450	5.46	47	79.23	29.95
12	1.650	.62	18	15.383	5.82	48	83.36	31.51
11	1.806	.68	19	16.367	6.19	49	87.67	33.14
—10	1.974	0.75	20	17.406	6.58	50	92.17	34.84
9	2.154	.81	21	18.503	6.99	51	96.87	36.62
8	2.347	.89	22	19.661	7.43	52	101.77	38.47
7	2.557	.97	23	20.883	7.90	53	106.88	40.40
6	2.785	1.05	24	22.178	8.38	54	112.21	42.42
—5	3.032	1.15	25	23.546	8.90	55	117.77	44.52
4	3.299	1.25	26	24.987	9.45	56	123.56	46.71
3	3.586	1.36	27	26.505	10.02	57	129.59	48.98
2	3.894	1.47	28	28.103	10.62	58	135.87	51.36
1	4.223	1.60	29	29.785	11.26	59	142.41	53.83
0	4.579	1.73	30	31.555	11.93	60	149.21	56.40

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* This table is quoted from "Smithsonian Meteorological Tables," p. 225.

DENSITY OF AIR FOR DIFFERENT PRESSURES AND HUMIDITIES.

TABLE 144. — Values of $\frac{h}{760}$, from $h = 1$ to $h = 9$, for the Computation of Different Values of the Ratio of Actual to Normal Barometric Pressure.

This gives the density of air at pressure h in terms of the density at normal atmosphere pressure. When the air contains moisture, as is usually the case with the atmosphere, we have the following equation for the dry air pressure: $h = B - 0.378e$, where e is the vapor pressure, and B the observed barometric pressure corrected for temperature. When the necessary observations are made the value of e may be taken from Table 170, and then 0.378e from Table 172, or the dew-point may be found and the value of 0.378e taken from Table 172.

h	$\frac{h}{760}$
1	0.0013158
2	.0026316
3	.0039474
4	0.0052632
5	.0065789
6	.0078947
7	0.0092105
8	.0105263
9	.0118421

EXAMPLES OF USE OF THE TABLE.

To find the value of $\frac{h}{760}$ when $h = 754.3$

$h = 700$	gives	.92105
50	"	.065789
4	"	.005263
.3	"	.000395
754.3		.992497

To find the value of $\frac{h}{760}$ when $h = 5.73$

$h = 5$	gives	.0065789
.7	"	.0007895
.03	"	.0000395
5.73		.0074079

TABLE 145. — Values of the logarithms of $\frac{h}{760}$ for values of h between 80 and 340.

Values from 8 to 80 may be got by subtracting 1 from the characteristic, and from 0.8 to 8 by subtracting 2 from the characteristic, and so on.

h	Values of log $\frac{h}{760}$.									
	0	1	2	3	4	5	6	7	6	9
80	$\bar{1}.02228$	$\bar{1}.02767$	$\bar{1}.03300$	$\bar{1}.03826$	$\bar{1}.04347$	$\bar{1}.04861$	$\bar{1}.05368$	$\bar{1}.05871$	$\bar{1}.06367$	$\bar{1}.06858$
90	.07343	.07823	.08297	.08767	.09231	.09691	.10146	.10596	.11041	.11482
100	$\bar{1}.11919$	$\bar{1}.12351$	$\bar{1}.12779$	$\bar{1}.13202$	$\bar{1}.13622$	$\bar{1}.14038$	$\bar{1}.14449$	$\bar{1}.14857$	$\bar{1}.15261$	$\bar{1}.15661$
110	.16058	.16451	.16840	.17226	.17609	.17988	.18364	.18737	.19107	.19473
120	.19837	.20197	.20555	.20909	.21261	.21611	.21956	.22299	.22640	.22978
130	.23313	.23646	.23976	.24304	.24629	.24952	.25273	.25591	.25907	.26220
140	.26531	.26841	.27147	.27452	.27755	.28055	.28354	.28650	.28945	.29237
150	$\bar{1}.29528$	$\bar{1}.29816$	$\bar{1}.30103$	$\bar{1}.30388$	$\bar{1}.30671$	$\bar{1}.30952$	$\bar{1}.31231$	$\bar{1}.31509$	$\bar{1}.31784$	$\bar{1}.32058$
160	.32331	.32601	.32870	.33137	.33403	.33667	.33929	.34190	.34450	.34707
170	.34964	.35218	.35471	.35723	.35974	.36222	.36470	.36716	.36961	.37204
180	.37446	.37686	.37926	.38164	.38400	.38636	.38870	.39128	.39334	.39565
190	.39794	.40022	.40249	.40474	.40699	.40922	.41144	.41365	.41585	.41804
200	$\bar{1}.42022$	$\bar{1}.42238$	$\bar{1}.42454$	$\bar{1}.42668$	$\bar{1}.42882$	$\bar{1}.43094$	$\bar{1}.43305$	$\bar{1}.43516$	$\bar{1}.43725$	$\bar{1}.43933$
210	.44141	.44347	.44552	.44757	.44960	.45162	.45364	.45565	.45764	.45963
220	.46161	.46358	.46554	.46749	.46943	.47137	.47329	.47521	.47712	.47902
230	.48091	.48280	.48467	.48654	.48840	.49025	.49210	.49393	.49576	.49758
240	.49940	.50120	.50300	.50479	.50658	.50835	.51012	.51188	.51364	.51539
250	$\bar{1}.51713$	$\bar{1}.51886$	$\bar{1}.52059$	$\bar{1}.52231$	$\bar{1}.52402$	$\bar{1}.52573$	$\bar{1}.52743$	$\bar{1}.52912$	$\bar{1}.53081$	$\bar{1}.53249$
260	.53416	.53583	.53749	.53914	.54079	.54243	.54407	.54570	.54732	.54894
270	.55055	.55216	.55376	.55535	.55694	.55852	.56010	.56167	.56323	.56479
280	.56634	.56789	.56944	.57097	.57250	.57403	.57555	.57707	.57858	.58008
290	.58158	.58308	.58457	.58605	.58753	.58901	.59048	.59194	.59340	.59486
300	$\bar{1}.59631$	$\bar{1}.59775$	$\bar{1}.59919$	$\bar{1}.60063$	$\bar{1}.60206$	$\bar{1}.60349$	$\bar{1}.60491$	$\bar{1}.60632$	$\bar{1}.60774$	$\bar{1}.60914$
310	.61055	.61195	.61334	.61473	.61611	.61750	.61887	.62025	.62161	.62298
320	.62434	.62569	.62704	.62839	.62973	.63107	.63240	.63373	.63506	.63638
330	.63770	.63901	.64032	.64163	.64293	.64423	.64553	.64682	.64810	.64939
340	.65067	.65194	.65321	.65448	.65574	.65701	.65826	.65952	.66077	.66201

TABLE 145 (*continued*).

DENSITY OF AIR.

Values of logarithms of $\frac{h}{760}$ for values of h between 350 and 800.

h	Values of log $\frac{h}{760}$.									
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
350	$\bar{1}.66325$	$\bar{1}.66449$	$\bar{1}.66573$	$\bar{1}.66696$	$\bar{1}.66819$	$\bar{1}.66941$	$\bar{1}.67064$	$\bar{1}.67185$	$\bar{1}.67307$	$\bar{1}.67428$
360	.67549	.67669	.67790	.67909	.68029	.68148	.68267	.68385	.68503	.68621
370	.68739	.68856	.68973	.69090	.69206	.69322	.69437	.69553	.69668	.69783
380	.69897	.70011	.70125	.70239	.70352	.70465	.70577	.70690	.70802	.70914
390	.71025	.71136	.71247	.71358	.71468	.71578	.71688	.71798	.71907	.72016
400	$\bar{1}.72125$	$\bar{1}.72233$	$\bar{1}.72341$	$\bar{1}.72449$	$\bar{1}.72557$	$\bar{1}.72664$	$\bar{1}.72771$	$\bar{1}.72878$	$\bar{1}.72985$	$\bar{1}.73091$
410	.73197	.73303	.73408	.73514	.73619	.73723	.73828	.73932	.74036	.74140
420	.74244	.74347	.74450	.74553	.74655	.74758	.74860	.74961	.75063	.75164
430	.75265	.75366	.75467	.75567	.75668	.75768	.75867	.75967	.76066	.76165
440	.76264	.76362	.76461	.76559	.76657	.76755	.76852	.76949	.77046	.77143
450	$\bar{1}.77240$	$\bar{1}.77336$	$\bar{1}.77432$	$\bar{1}.77528$	$\bar{1}.77624$	$\bar{1}.77720$	$\bar{1}.77815$	$\bar{1}.77910$	$\bar{1}.78005$	$\bar{1}.78100$
460	.78194	.78289	.78383	.78477	.78570	.78664	.78757	.78850	.78943	.79036
470	.79128	.79221	.79313	.79405	.79496	.79588	.79679	.79770	.79861	.79952
480	.80043	.80133	.80223	.80313	.80403	.80493	.80582	.80672	.80761	.80850
490	.80938	.81027	.81115	.81203	.81291	.81379	.81467	.81554	.81642	.81729
500	$\bar{1}.81816$	$\bar{1}.81902$	$\bar{1}.81989$	$\bar{1}.82075$	$\bar{1}.82162$	$\bar{1}.82248$	$\bar{1}.82334$	$\bar{1}.82419$	$\bar{1}.82505$	$\bar{1}.82590$
510	.82676	.82761	.82846	.82930	.83015	.83099	.83184	.83268	.83352	.83435
520	.83519	.83602	.83686	.83769	.83852	.83935	.84017	.84100	.84182	.84264
530	.84346	.84428	.84510	.84591	.84673	.84754	.84835	.84916	.84997	.85076
540	.85158	.85238	.85319	.85399	.85479	.85558	.85638	.85717	.85797	.85876
550	$\bar{1}.85955$	$\bar{1}.86034$	$\bar{1}.86113$	$\bar{1}.86191$	$\bar{1}.86270$	$\bar{1}.86348$	$\bar{1}.86426$	$\bar{1}.86504$	$\bar{1}.86582$	$\bar{1}.86660$
560	.86737	.86815	.86892	.86969	.87047	.87123	.87200	.87277	.87353	.87430
570	.87506	.87282	.87658	.87734	.87810	.87885	.87961	.88036	.88111	.88186
580	.88261	.88336	.88411	.88486	.88560	.88634	.88708	.88782	.88856	.88930
590	.89004	.89077	.89151	.89224	.89297	.89370	.89443	.89516	.89589	.89661
600	$\bar{1}.89734$	$\bar{1}.89806$	$\bar{1}.89878$	$\bar{1}.89950$	$\bar{1}.90022$	$\bar{1}.90094$	$\bar{1}.90166$	$\bar{1}.90238$	$\bar{1}.90309$	$\bar{1}.90380$
610	.90452	.90523	.90594	.90665	.90735	.90806	.90877	.90947	.91017	.91088
620	.91158	.91228	.91298	.91367	.91437	.91507	.91576	.91645	.91715	.91784
630	.91853	.91922	.91990	.92059	.92128	.92196	.92264	.92333	.92401	.92469
640	.92537	.92604	.92672	.92740	.92807	.92875	.92942	.93009	.93076	.93143
650	$\bar{1}.93210$	$\bar{1}.93277$	$\bar{1}.93343$	$\bar{1}.93410$	$\bar{1}.93476$	$\bar{1}.93543$	$\bar{1}.93609$	$\bar{1}.93675$	$\bar{1}.93741$	$\bar{1}.93807$
660	.93873	.93939	.94004	.94070	.94135	.94201	.94266	.94331	.94396	.94461
670	.94526	.94591	.94656	.94720	.94785	.94849	.94913	.94978	.95042	.95106
680	.95170	.95233	.95297	.95361	.95424	.95488	.95551	.95614	.95677	.95741
690	.95804	.95866	.95929	.95992	.96055	.96117	.96180	.96242	.96304	.96366
700	$\bar{1}.96428$	$\bar{1}.96490$	$\bar{1}.96552$	$\bar{1}.96614$	$\bar{1}.96676$	$\bar{1}.96738$	$\bar{1}.96799$	$\bar{1}.96861$	$\bar{1}.96922$	$\bar{1}.96983$
710	.97044	.97106	.97167	.97228	.97288	.97349	.97410	.97471	.97531	.97592
720	.97652	.97712	.97772	.97832	.97892	.97951	.98012	.98072	.98132	.98191
730	.98251	.98310	.98370	.98429	.98488	.98547	.98606	.98665	.98724	.98783
740	.98842	.98900	.98959	.99018	.99076	.99134	.99193	.99251	.99309	.99367
750	$\bar{1}.99425$	$\bar{1}.99483$	$\bar{1}.99540$	$\bar{1}.99598$	$\bar{1}.99656$	$\bar{1}.99713$	$\bar{1}.99771$	$\bar{1}.99828$	$\bar{1}.99886$	$\bar{1}.99942$
760	0.00000	0.00057	0.00114	0.00171	0.00228	0.00285	0.00342	0.00398	0.00455	0.00511
770	.00568	.00624	.00680	.00737	.00793	.00849	.00905	.00961	.01017	.01072
780	.01128	.01184	.01239	.01295	.01350	.01406	.01461	.01516	.01571	.01626
790	.01681	.01736	.01791	.01846	.01901	.01955	.02010	.02064	.02119	.02173

TABLE 146.

VOLUME OF PERFECT GASES.

Values of $1+.00367t$.

The quantity $1+.00367t$ gives for a perfect gas the volume at $t°$ when the pressure is kept constant, or the pressure at $t°$ when the volume is kept constant, in terms of the volume or the pressure at 0°.

(a) This part of the table gives the values of $1+.00367t$ for values of t between 0° and 10° C. by tenths of a degree.

(b) This part gives the values of $1+.00367t$ for values of t between —90° and +1990° C. by 10° steps.

These two parts serve to give any intermediate value to one tenth of a degree by a simple computation as follows: — In the (*b*) table find the number corresponding to the nearest lower temperature, and to this number add the decimal part of the number in the (*a*) table which corresponds to the difference between the nearest temperature in the (*b*) table and the actual temperature. For example, let the temperature be 682°.2:

We have for 680 in table (*b*) the number	3.49560
And for 2.2 in table (*a*) the decimal	.00807
Hence the number for 682.2 is	3.50367

(c) This part gives the logarithms of $1+.00367t$ for values of t between —49° and +399° C. by degrees.

(d) This part gives the logarithms of $1+.00367t$ for values of t between 400° and 1990° C. by 10° steps.

(a) Values of $1+.00367t$ for Values of t between 0° and 10° C. by Tenths of a Degree.

t	0.0	0.1	0.2	0.3	0.4
0	1.00000	1.00037	1.00073	1.00110	1.00147
1	.00367	.00404	.00440	.00477	.00514
2	.00734	.00771	.00807	.00844	.00881
3	.01101	.01138	.01174	.01211	.01248
4	.01468	.01505	.01541	.01578	.01615
5	1.01835	1.01872	1.01908	1.01945	1.01982
6	.02202	.02239	.02275	.02312	.02349
7	.02569	.02606	.02642	.02679	.02716
8	.02936	.02973	.03009	.03046	.03083
9	.03303	.03340	.03376	.03413	.03450

t	0.5	0.6	0.7	0.8	0.8
0	1.00184	1.00220	1.00257	1.00294	1.00330
1	.00550	.00587	.00624	.00661	.00697
2	.00918	.00954	.00991	.01028	.01064
3	.01284	.01321	.01358	.01395	.01431
4	.01652	.01688	.01725	.01762	.01798
5	1.02018	1.02055	1.02092	1.02129	1.02165
6	.02386	.02422	.02459	.02496	.02532
7	.02752	.02789	.02826	.02863	.02899
8	.03120	.03156	.03193	.03290	.03266
9	.03486	.03523	.03560	.03597	.03633

TABLE 146 (*continued*).

VOLUME OF PERFECT GASES.

(b) Values of $1+.00367t$ for Values of t between $-90°$ and $+1990°$ C. by 10° Steps.

t	00	10	20	30	40
−000	1.00000	0.96330	0.92660	0.88990	0.85320
+000	1.00000	1.03670	1.07340	1.11010	1.14680
100	1.36700	1.40370	1.44040	1.47710	1.51380
200	1.73400	1.77070	1.80740	1.84410	1.88080
300	2.10100	2.13770	2.17440	2.21110	2.24780
400	2.46800	2.50470	2.54140	2.57810	2.61480
500	2.83500	2.87170	2.90840	2.94510	2.98180
600	3.20200	3.23870	3.27540	3.31210	3.34880
700	3.56900	3.60570	3.64240	3.67910	3.71580
800	3.93600	3.97270	4.00940	4.04610	4.08280
900	4.30300	4.33970	4.37640	4.41310	4.44980
1000	4.67000	4.70670	4.74340	4.78010	4.81680
1100	5.03700	5.07370	5.11040	5.14710	5.18380
1200	5.40400	5.44070	5.47740	5.51410	5.55080
1300	5.77100	5.80770	5.84440	5.88110	5.91780
1400	6.13800	6.17470	6.21140	6.24810	6.28480
1500	6.50500	6.54170	6.57840	6.61510	6.65180
1600	6.87200	6.90870	6.94540	6.98210	7.01880
1700	7.23900	7.27570	7.31240	7.34910	7.38580
1800	7.60600	7.64270	7.67940	7.71610	7.75280
1900	7.97300	8.00970	8.04640	8.08310	8.11980
2000	8.34000	8.37670	8.41340	8.45010	8.48680

t	50	60	70	90	90
−000	0.81650	0.77980	0.74310	0.70640	0.66970
+000	1.18350	1.22020	1.25690	1.29360	1.33030
100	1.55050	1.58720	1.62390	1.66060	1.69730
200	1.91750	1.95420	1.99090	2.02760	2.06430
300	2.28450	2.32120	2.35790	2.39460	2.43130
400	2.65150	2.68820	2.72490	2.76160	2.79830
500	3.01850	3.05520	3.09190	3.12860	3.16530
600	3.38550	3.42220	3.45890	3.49560	3.53230
700	3.75250	3.78920	3.82590	3.86260	3.89930
800	4.11950	4.15620	4.19290	4.22960	4.26630
900	4.48650	4.52320	4.55990	4.59660	4.63330
1000	4.85350	4.89020	4.92690	4.96360	5.00030
1100	5.22050	5.25720	5.29390	5.33060	5.36730
1200	5.58750	5.62420	5.66090	5.69760	5.73430
1300	5.95450	5.99120	6.02790	6.06460	6.10130
1400	6.32150	6.35820	6.39490	6.43160	6.46830
1500	6.68850	6.72520	6.76190	6.79860	6.83530
1600	7.05550	7.09220	7.12890	7.16560	7.20230
1700	7.42250	7.45920	7.49590	7.53260	7.56930
1800	7.78950	7.82620	7.86290	7.89960	7.93630
1900	8.15650	8.19320	8.22990	8.26660	8.30330
2000	8.52350	8.56020	8.59690	8.63360	8.67030

VOLUME OF

(c) Logarithms of 1 + .00367 *t* for Values

t	0	1	2	3	4	Mean diff. per degree.
— 40	$\bar{1}$.931051	$\bar{1}$.929179	$\bar{1}$.927299	$\bar{1}$.925410	$\bar{1}$.923513	**1884**
— 30	.949341	.947546	.945744	.943934	.942117	1805
— 20	.966892	.965169	.963438	.961701	.959957	1733
—10	.983762	.982104	.980440	.978769	.977092	1667
— 0	0.000000	.998403	.996801	.995192	.993577	1605
+ 0	0.000000	0.001591	0.003176	0.004755	0.006329	**1582**
10	.015653	.017188	.018717	.020241	.021760	1526
20	.030762	.032244	.033721	.035193	.036661	1474
30	.045362	.046796	.048224	.049648	.051068	1426
40	.059488	.060875	.062259	.063637	.065012	1381
50	0.073168	0.074513	0.075853	0.077190	0.078522	**1335**
60	.086431	.087735	.089036	.090332	.091624	1299
70	.099301	.100567	.101829	.103088	.104344	1259
80	.111800	.113030	.114257	.115481	.116701	1226
90	.123950	.125146	.126339	.127529	.128716	1191
100	0.135768	0.136933	0.138094	0.139252	0.140408	**1158**
110	.147274	.248408	.149539	.150667	.151793	1129
120	.158483	.159588	.160691	.161790	.162887	1101
130	.169410	.170488	.171563	.172635	.173705	1074
140	.180068	.181120	.182169	.183216	.184260	1048
150	0.190472	0.191498	0.192523	0.193545	0.194564	**1023**
160	.200632	.201635	.202635	.203634	.204630	1000
170	.210559	.211540	.212518	.213494	.214468	976
180	.220265	.221224	.222180	.223135	.224087	956
190	.229759	.230697	.231633	.232567	.233499	935
200	0.239049	0.239967	0.240884	0.241798	0.242710	**916**
210	.248145	.249044	.249942	.250837	.251731	897
220	.257054	.257935	.258814	.259692	.260567	878
230	.265784	.266648	.267510	.268370	.269228	861
240	.274343	.275189	.276034	.276877	.277719	844
250	0.282735	0.283566	0.284395	0.285222	0.286048	**828**
260	.290969	.291784	.292597	.293409	.294219	813
270	.299049	.299849	.300648	.301445	.302240	798
280	.306982	.307768	.308552	.309334	.310115	784
290	.314773	.315544	.316314	.317083	.317850	769
300	0.322426	0.323184	0.323941	0.324696	0.325450	**756**
310	.329947	.330692	.331435	.332178	.332919	743
320	.337339	.338072	.338803	.339533	.340262	730
330	.344608	.345329	.345048	.346766	.347482	719
340	.351758	.352466	.353174	.353880	.354585	707
350	0.358791	0.359488	0.360184	0.360879	0.361573	**696**
360	.365713	.366399	.367084	.367768	.368451	684
370	.372525	.373201	.373875	.374549	.375221	674
380	.379233	.379898	.380562	.381225	.381887	664
390	.385439	.386494	.387148	.387801	.388453	654

PERFECT GASES.

of *t* between −49° and +399° C. by Degrees.

t	5	6	7	8	9	Mean diff. per degree.
−40	$\bar{1}$.921608	$\bar{1}$.919695	$\bar{1}$.917773	$\bar{1}$.915843	$\bar{1}$.913904	1926
−30	.940292	.938460	.936619	.934771	.932915	1845
−20	.958205	.956447	.954681	.952909	.951129	1771
−10	.975409	.973719	.972022	.970319	.968609	1699
−0	.991957	.990330	.988697	.987058	.985413	1636
+0	0.007897	0.009459	0.011016	0.012567	0.014113	1554
10	.023273	.024781	.026284	.027782	.029274	1500
20	.038123	.039581	.041034	.042481	.043924	1450
30	.052482	.053893	.055298	.056699	.058096	1402
40	.066382	.067748	.069109	.070466	.071819	1359
50	0.079847	0.081174	0.082495	0.083811	0.085123	1315
60	.092914	.094198	.095486	.096765	.098031	1281
70	.105595	.106843	.108088	.109329	.110566	1243
80	.117917	.119130	.120340	.121547	.122750	1210
90	.129899	.131079	.132256	.133430	.134601	1175
100	0.141559	0.142708	0.143854	0.144997	0.146137	1144
110	.152915	.154034	.155151	.156264	.157375	1115
120	.163981	.164072	.166161	.167246	.168330	1087
130	.174772	.175836	.176898	.177958	.179014	1060
140	.185301	.186340	.187377	.188411	.189443	1035
150	0.195581	0.196596	0.197608	0.198619	0.199626	1011
160	.205624	.206615	.207605	.208592	.209577	988
170	.215439	.216409	.217376	.218341	.219304	966
180	.225038	.225986	.226932	.227876	.228819	946
190	.234429	.235357	.236283	.237207	.238129	925
200	0.243621	0.244529	0.245436	0.246341	0.247244	906
210	.252623	.253512	.254400	.255287	.256172	887
220	.261441	.262313	.263184	.264052	.264919	870
230	.270085	.270940	.271793	.272644	.273494	853
240	.278559	.279398	.280234	.281070	.281903	836
250	0.286872	0.287694	0.288515	0.289326	0.290153	820
260	.295028	.295835	.296640	.297445	.298248	805
270	.303034	.303827	.304618	.305407	.306196	790
280	.310895	.311673	.312450	.313226	.314000	776
290	.318616	.319381	.320144	.320906	.321667	763
300	0.326203	0.326954	0.327704	0.328453	0.329201	750
310	.333659	.334397	.335135	.335871	.336606	737
320	.340989	.341715	.342441	.343164	.343887	724
330	.348198	.348912	.349624	.350337	.351048	713
340	.355289	.355991	.356693	.357394	.358093	701
350	0.362266	0.362957	0.363648	0.364337	0.365025	690
360	.369132	.369813	.370493	.371171	.371849	678
370	.375892	.376562	.377232	.377900	.378567	668
380	.382548	.383208	.383868	.384525	.385183	658
390	.389104	.389754	.390403	.391052	.391699	648

VOLUME OF PERFECT CASES.

(d) Logarithms of 1 + .00367 *t* for Values of *t* between 400° and 1990° C. by 10° Steps.

t	00	10	20	30	40
400	0.392345	0.398756	0.405073	0.411300	0.417439
500	0.452553	0.458139	0.463654	0.469100	0.474479
600	.505421	.510371	.515264	.520103	.524889
700	.552547	.556990	.561388	.565742	.570052
800	.595055	.599086	.603079	.607037	.610958
900	.633771	.637460	.641117	.644744	.648341
1000	0.669317	0.672717	0.676090	0.679437	0.682759
1100	.702172	.705325	.708455	.711563	.714648
1200	.732715	.735655	.738575	.741475	.744356
1300	.761251	.764004	.766740	.769459	.772160
1400	.788027	.790616	.793190	.795748	.798292
1500	0.813247	0.815691	0.818120	0.820536	0.822939
1600	.837083	.839396	.841697	.843986	.846263
1700	.859679	.861875	.864060	.866234	.868398
1800	.881156	.883247	.885327	.887398	.889459
1900	.901622	.903616	.905602	.907578	.909545

t	50	60	70	80	90
400	0.423492	0.429462	0.435351	0.441161	0.446894
500	0.479791	0.485040	0.490225	0.495350	0.500415
600	.529623	.534305	.538938	.543522	.548058
700	.574321	.578548	.582734	.586880	.590987
800	.614845	.618696	.622515	.626299	.630051
900	.651908	.655446	.658955	.662437	.665890
1000	0.686055	0.689327	0.692574	0.695797	0.698996
1100	.717712	.720755	.723776	.726776	.729756
1200	.747218	.750061	.752886	.755692	.758480
1300	.774845	.777514	.780166	.782802	.785422
1400	.800820	.803334	.805834	.808319	.810790
1500	0.825329	0.827705	0.830069	0.832420	0.834758
1600	.848528	.850781	.853023	.855253	.857471
1700	.870550	.872692	.874824	.876945	.879056
1800	.891510	.893551	.895583	.897605	.899618
1900	.911504	.913454	.915395	.917327	.919251

DETERMINATION OF HEIGHTS BY THE BAROMETER.

Formula of Babinet: $Z = C \frac{B_0 - B}{B_0 + B}$.

C (in feet) $= 52494 \left[1 + \frac{t_0 + t - 64}{900}\right]$ English measures.

C (in metres) $= 16000 \left[1 + \frac{2(t_0 + t)}{1000}\right]$ metric measures.

In which Z = difference of height of two stations in feet or metres.

B_0, B = barometric readings at the lower and upper stations respectively, corrected for all sources of instrumental error.

t_0, t = air temperatures at the lower and upper stations respectively.

Values of C.

ENGLISH MEASURES.			METRIC MEASURES.		
$\frac{1}{2}(t_0+t)$.	C	Log C	$\frac{1}{2}(t_0+t)$.	C	Log C
Fahr.	Feet.		Cent.	Metres.	
10°	49928	4.69834	**—10°**	15360	4.18639
15	50511	.70339	—8	15488	.19000
20	51094	4.70837	—6	15616	.19357
25	51677	.71330	—4	15744	.19712
			—2	15872	.20063
30	52261	4.71818	**0**	16000	4.20412
35	52844	.72300	+ 2	16128	.20758
40	53428	4.72777	4	16256	.21101
45	54011	.73248	6	16384	.21442
			8	16512	.21780
50	54595	4.73715	**10**	16640	4.22115
55	55178	.74177	12	16768	.22448
60	55761	4.74633	14	16896	.22778
65	56344	.75085	16	17024	.23106
			18	17152	.23431
70	56927	4.75532	**20**	17280	4.23754
75	57511	.75975	22	17408	.24075
80	58094	4.76413	24	17536	.24393
85	58677	.76847	26	17664	.24709
			28	17792	.25022
90	59260	4.77276	**30**	17920	4.25334
95	59844	.77702	32	18048	.25643
100	60427	4.78123	34	18176	.25950
			36	18304	.26255

TABLE 148.

BAROMETRIC

Barometric pressures corresponding to different
This table is useful when a boiling-point apparatus is used

(a) Common Measure.*

Temp. ° F.	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
185	17.06	17.09	17.13	17.17	17.20	17.24	17.28	17.32	17.35	17.39
186	17.42	17.47	17.51	17.54	17.58	17.62	17.66	17.70	17.74	17.77
187	17.81	17.85	17.89	17.93	17.97	18.01	18.05	18.08	18.12	18.16
188	18.20	18.24	18.28	18.32	18.36	18.40	18.44	18.48	18.52	18.56
189	18.60	18.64	18.68	18.72	18.76	18.80	18.84	18.88	18.92	18.96
190	19.00	19.04	19.08	19.12	19.16	19.21	19.25	19.29	19.33	19.37
191	19.41	19.45	19.49	19.54	19.58	19.62	19.66	19.70	19.75	19.79
192	19.83	19.87	19.91	19.96	20.00	20.04	20.08	20.13	20.17	20.21
193	20.26	20.30	20.34	20.38	20.43	20.47	20.51	20.56	20.60	20.64
194	20.68	20.73	20.78	20.82	20.86	20.91	20.95	20.99	21.04	21.08
195	21.13	21.17	21.22	21.26	21.31	21.35	21.40	21.44	21.48	21.53
196	21.58	21.62	21.67	21.71	21.76	21.80	21.85	21.90	21.94	21.99
197	22.03	22.08	22.13	22.17	22.22	22.27	22.31	22.36	22.41	22.45
198	22.50	22.55	22.59	22.64	22.69	22.73	22.78	22.83	22.88	22.92
199	22.97	23.02	23.07	23.12	23.16	23.21	23.26	23.31	23.36	23.40
200	23.45	23.50	23.55	23.60	23.65	23.70	23.75	23.79	23.84	23.89
201	23.94	23.99	24.04	24.09	24.14	24.19	24.24	24.29	24.34	24.39
202	24.44	24.49	24.54	24.59	24.64	24.69	24.74	24.79	24.85	24.90
203	24.95	25.00	25.05	25.10	25.15	25.20	25.26	25.31	25.36	25.41
204	25.46	25.52	25.57	25.62	25.67	25.72	25.78	25.83	25.88	25.94
205	25.99	26.04	26.09	26.15	26.20	26.25	26.31	26.36	26.41	26.47
206	26.52	26.58	26.63	26.68	26.74	26.79	26.85	26.90	26.96	27.01
207	27.06	27.12	27.17	27.23	27.28	27.34	27.39	27.45	27.51	27.56
208	27.62	27.67	27.73	27.78	27.84	27.90	27.95	28.01	28.07	28.12
209	28.18	28.24	28.29	28.35	28.41	28.46	28.52	28.58	28.63	28.69
210	28.75	28.81	28.87	28.92	28.98	29.04	29.10	29.16	29.21	29.27
211	29.33	29.39	29.45	29.51	29.57	29.63	29.68	29.74	29.80	29.86
212	29.92	29.98	30.04	30.10	30.16	30.22	30.28	30.34	30.40	30.46

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* Pressures in inches of mercury.

PRESSURES.

temperatures of the boiling-point of water.
in place of the barometer for the determination of heights.

(b) Metric Measure.*

Temp. ° C.	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
80°	354.9	356.3	357.8	359.2	360.7	362.1	363.6	365.1	366.5	368.0
81	369.5	371.0	372.5	374.0	375.5	377.0	378.5	380.0	381.6	383.1
82	384.6	386.2	387.7	389.3	390.8	392.4	394.0	395.5	397.1	398.7
83	400.3	401.9	403.5	405.1	406.7	408.3	409.9	411.6	413.2	414.8
84	416.5	418.1	419.8	421.4	423.1	424.8	426.4	428.1	429.8	431.5
85	433.2	434.9	436.6	438.3	440.0	441.8	443.5	445.2	447.0	448.7
86	450.5	452.2	454.0	455.8	457.5	459.3	461.1	462.9	464.7	466.5
87	468.3	470.1	472.0	473.8	475.6	477.5	479.3	481.2	483.0	484.9
88	486.8	488.6	490.5	492.4	494.3	496.2	498.1	500.0	501.9	503.9
89	505.8	507.7	509.7	511.6	513.6	515.6	517.5	519.4	521.5	523.5
90	525.5	527.5	529.5	531.5	533.5	535.5	537.6	539.6	541.6	543.7
91	545.8	547.8	549.9	552.0	554.1	556.2	558.3	560.4	562.5	564.6
92	566.7	568.8	571.0	573.1	575.3	577.4	579.6	581.8	584.0	586.1
93	588.3	590.5	592.7	595.0	597.2	599.4	601.6	603.9	606.1	608.4
94	610.6	612.9	615.2	617.5	619.8	622.1	624.4	626.7	629.0	631.3
95	633.7	636.0	638.4	640.7	643.1	645.4	647.8	650.2	652.6	655.0
96	657.4	659.8	662.3	664.7	667.1	669.5	672.0	674.5	676.9	679.4
97	681.9	684.4	686.9	689.4	691.9	694.5	696.9	699.5	702.0	704.6
98	707.1	709.7	712.3	714.9	717.4	720.0	722.7	725.3	727.9	730.5
99	733.2	735.8	738.5	741.1	743.8	746.5	749.2	751.9	754.6	757.3
100	760.0	762.7	765.5	768.2	771.0	773.7	776.5	779.3	782.1	784.9

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* Pressures in millimetres of mercury.

STANDARD WAVE-LENGTHS.

TABLE 149.—Standard Iron Lines. Fabry-Buisson Values.

Referred to the Cd line, λ=6438.4722.
Source: electric arc; current: 3-5 amperes; voltage: generally 110 volts.

Wave-length.	*	Wave-length.	*	Wave-length.	*	Wave-length.	*
2373.737	-	3513.820	—.145	4592.658	—.182	5455.616	—.218
2413.310	-	3556.879	—.157	4602.944	—.182	5497.521	—.214
2435.159 Si	-	3606.681	—.157	4647.437	—.180	5506.783	—.217
2506.904 Si	-	3640.391	—.144	4678.855	—.172	5535.418	—.226
2528.516	-	3677.628	—.136	4707.287	—.170	5569.632	—.216
2562.541	-	3724.379	—.147	4736.785	—.178	5586.770	—.221
2588.016	-	3753.615	—.117	4754.046 Mn	—.179	5615.658	—.219
2628.296	-	3805.346	—.140	4789.657	—.192	5658.835	—.217
2679.065		3843.261	—.143	4823.521 Mn	—.176	5709.396	—.205
2714.419	-	3865.526	—.148	4859.756	—.172	5760.843 Ni	—.209
2739.550	-	3906.481	—.147	4878.226	—.181	5763.013	—.205
2778.225	-	3935.818	—.147	4903.324	—.178	5805.211 Ni	—.230
2813.290	-	3977.745	—.146	4919.006	—.168	5857.760 Ni	—.216
2851.800	-	4021.872	—.146	4966.104	—.166	5892.882 Ni	—.215
2874.176	-	4076.641	—.151	5001.880	—.164	5934.683	—.198
2912.157	-	4118.552	—.156	5012.072	—.180	5952.739	—.204
2941.347	-	4134.685	—.155	5049.827	—.181	6003.039	—.200
2987.293	—.146	4147.677	—.159	5083.343	—.175	6027.059	—.215
3030.152	—.109	4191.441	—.154	5110.415	—.159	6065.493	—.216
3075.725	—.115	4233.615	—.157	5127.364	—.169	6137.700	—.215
3125.661	—.118	4282.407	—.158	5167.492	—.186	6191.569	—.210
3175.447	—.115	4315.089	—.173	5192.362	—.161	6230.732	—.211
3225.790	—.129	4352.741	—.167	5232.958	—.164	6265.147	—.201
3271.003	—.126	4375.935	—.172	5266.568	—.169	6318.029	—.210
3323.739	—.142	4427.314	—.168	5302.316	—.164	6335.343	—.211
3370.789	—.144	4466.554	—.173	5324.196	—.177	6393.612	—.208
3399.337	—.152	4494.572	—.166	5371.498	—.236	6430.859	—.207
3445.155	—.105	4531.155	—.172	5405.780	—.209	6494.994	—.219
3485.344	—.149	4547.854	—.170	5434.530	—.210		

Taken from Fabry and Buisson, Astrophysical Journal, 28, 1908.

* These columns give the differences: Fabry-Buisson minus the corresponding iron line in Rowland's Preliminary Table of Solar Spectrum Wave-lengths.

TABLE 150.—Absolute Wave-length of Red Cadmium Line in Air, 760 mm. Pressure, 15° C.

6438.4722........Michelsen.
6438.4696........Fabry and Perot.

For arc and spark lines of titanium, manganese, and vanadium (on above system of wave-lengths), see Kilby, Astrophysical Journal, 30, 1909.

TABLE 151.—Some of the Stronger Lines of Some of the Elements.

Barium .	5535.7	Helium .	5875.8	Magnesium	5167.5	Sodium .	5890.2
Cæsium .	4555.4	" . .	5876.2	" . .	5172.9	" . .	5896.2
" . .	4593.3	Hydrogen	4101.8	" . .	5183.8	Strontium	4607.5
Calcium .	5589.0	" . .	4340.7	Mercury . .	5461.0	" . .	5481.2
Cadmium	4799.9	" . .	4861.5	Potassium .	7668.5	" . .	6408.6
" . .	5085.8	" . .	6563.0	" . .	7701.9	Thallium .	5350.6
" . .	6438.5	Lithium .	6708.2	Rubidium .	6298.7		

TABLE 152.

STANDARD SOLAR WAVE-LENGTHS. ROWLAND'S VALUES.

Wave-lengths are in Ångström units (10^{-7} mm.), in air at 20° C and 76 cm. of mercury pressure. The intensities run from 1, just clearly visible on the map, to 1000 for the H and K lines; below 1 in order of faintness to 0000 as the lines are more and more difficult to see. This table contains only the lines above 5.

N indicates a line not clearly defined, probably an undissolved multiple line; s, a faded appearing line; d, a double. In the "substance" column, where two or more elements are given, the line is compound; the order in which they are given indicates the portion of the line due to each element; when the solar line is too strong to be due wholly to the element given, it is represented, –**Fe**, for example; when commas separate the elements instead of a dash, the metallic lines coincide with the same part of the solar line, **Fe**, **Cr**, for example.

Capital letters next the wave-length numbers are the ordinary designations of the lines. A indicates atmospheric lines, (wv), due to water vapor, (O), due to Oxygen.

Wave-length.	Substance.	Intensity.	Wave-length.	Substance.	Intensity.	Wave-length.	Substance.	Intensity.
3037.510s	Fe	10 N	3372.947	Ti–Pd	10 d?	3533.345	Fe	6
3047.725s	Fe	20 N	3380.722	Ni	6 N	3536.709	Fe	7
3053.530s	–	7 d?	3414.911	Ni	15	3541.237	Fe	7
3054.429	Mn, Ni	10	3423.848	Ni	7	3542.232	Fe	6
3057.552s	Ti, Fe	20	3433.715	Ni, Cr	8 d?	3555.079	Fe	9
3059.212s	Fe	20	3440.762s } O	Fe	20	3558.672s	Fe	8
3067.369s	Fe	8	3441.155s	Fe	15	3565.535s	Fe	12
3073.091	Ti, –	6 Nd?	3442.118	Mn	6	3566.522	Ni	10
3078.769s	Ti, –	8 d?	3444.020s	Fe	8 N	3570.273s	Fe	20
3088.145s	Ti	7 d?	3446.406	Ni	15	3572.014	Ni	6
3134.230s	Ni, Fe	8	3449.583	Co	6 d?	3572.712	Se, –	6
3188.656	–, Fe	6 d?	3453.039	Ni	6 d?	3578.832	Cr	10
3236.703s	Ti	7 N	3458.601	Ni	8	3581.349s	Fe	30
3239.170	Ti	7	3461.801	Ni	8	3584.800	Fe	6
3242.125	Ti, –	8	3462.950	Co	6	3585.105	Fe	6
3243.189	–, Ni	6	3466.015s	Fe	6	3585.479	Fe	7
3247.688s	Cu	10	3475.594s	Fe	10	3585.859	Fe	6
3256.021	Fe?	6	3476.849s	Fe	8	3587.130	Fe	8
3267.834s	V	6	3483.923	Ni	6 d?	3587.370	Co	7
3271.129	Fe	6	3485.493	Fe Co	6	3588.084	Ni	6
3271.791	Ti, Fe	6 d?	3490.733s	Fe	10 N	3593.636	Cr	9
3274.096s	Cu	10	3493.114	Ni	10 N	3594.784	Fe	6
3277.482	Co–Fe	7 d?	3497.982s	Fe	8	3597.854	Ni	8
3286.898	Fe	7 N	3500.996s	Ni	6 d?	3605.479s	Cr	7
3295.951s	Fe, Mn	6	3510.466	Ni	8	3606.838s	Fe	6
3302.510s	Na	6	3512.785	Co	6	3609.008s	Fe	20
3315.807	Ni	7 d?	3513.965s	Fe	7	3612.882	Ni	6 d?
3318.160s	Ti	6	3515.206	Ni	12	3617.934s	Fe	6
3320.391	Ni	7	3519.904	N	7	3618.919s	Fe	20
3336.820	Mg	8 N	3521.410s	Fe	8	3619.539	Ni	8
3349.597	Ti	7	3524.677	Ni	20	3621.612s	Fe	6
3361.327	Ti	8	3526.183	Fe	6	3622.147s	Fe	6
3365.908	Ni	6	3526.988	Co	6	3631.605s	Fe	15
3366.311	Ti, Ni	6 d?	3529.964	Fe–Co	6	3640.535s	Cr–Fe	6
3369.713	Fe, Ni	.6	3533.156	Fe	6	3642.820	Ti	7

Corrections to reduce Rowland's wave-lengths to Fabry and Buisson's system (the accepted standard, 1908). Temperature 15° C pressure 760 mm.

The differences "(Fabry-Buisson-arc-iron) — (Rowland-solar-iron)" lines were plotted, a smooth curve drawn, and the following values obtained:

Wave-length	3000.	3100.	3200.	3300.	3400.	3500.	3600.	3700.
Correction	—.106	—.115	—.124	—.137	—.148	—.154	—.155	—.140

H. A. Rowland, "A preliminary table of solar-spectrum wave-lengths," Astrophysical Journal, 1–6, 1895–1897.

STANDARD SOLAR WAVE-LENGTHS. ROWLAND'S VALUES.

Wave-length.	Substance.	Intensity.	Wave-length.	Substance.	Intensity.	Wave-length.	Substance.	Intensity.
3647.988s	Fe	12	3826.027s	Fe	20	4045.975s	Fe	30
3651.247	Fe,–	6	3827.980	Fe	80	4055.701s	Mn	6
3651.614	Fe	7	3829.501s	Mg	10	4057.668	–	7
3676.457	Fe, Cr	6	3831.837	Ni	6	4063.759s	Fe	20
3680.069s	Fe	9	3832.450s	Mg	15	4068.137	Fe–Mn	6
3684.258s	Fe	7d?	3834.364	Fe	10	4071.908s	Fe	15
3685.339	Ti	10d?	3838.435s	Mg–C	25	4077.885s	Sr	8
3686.141	Ti–Fe	6	3840.580s	Fe–C	8	4102.000Hδ	H, In	40N
3687.610s	Fe	6	3841.195	Fe–Mn	10	4121.477s	Cr–Co	6d?
3689.614	Fe	6	3845.606	C–Co	8d?	4128.251	Ce–V,–	6d
3701.234	Fe	8	3850.118	Fe–Cr	10	4132.235	Fe–Co	10
3705.708s	Fe	9	3856.524s	Fe	8	4137.156	Fe	6
3706.175	Ca, Mn	6d?	3857.805	Cr–C	6d?	4140.089	Fe	6
3709.389s	Fe	8	3858.442	Ni	7	4144.038	Fe	15
3716.591s	Fe	7	3860.055s	Fe–C	20	4167.438	–	8
3720.084s	Fe	40	3865.674	Fe–C	7	4187.204	Fe	6
3722.692s	Ni	10	3872.639	Fe	6	4191.595	Fe	6
3724.526	Fe	6	3878.152	Fe–C	8	4202.198s	Fe	8
3732.545s	Co–Fe	6	3878.720	Fe	7Nd?	4226.904sg	Ca	20d?
3733.469s	Fe–	7d?	3886.434s	Fe	15	4233.772	Fe	6
3735.014s	Fe	40	3887.196	Fe	7	4236.112	Fe	8
3737.281s	Fe	30	3894.211	–	8d	4250.287s	Fe	8
3738.466	–	6	3895.803	Fe	7	4250.945s	Fe	8
3743.508	Fe–Ti	6	3899.850	Fe	8	4254.505s	Cr	8
3745.717s	Fe	8	3903.090	Cr, Fe, Mo	10	4260.640s	Fe	10
3746.058s	Fe	6	3904.023	–	8d	4271.934s	Fe	15
3748.408s	Fe	10	3905.660s	Si	12	4274.958s	Cr	7d?
3749.631s	Fe	20	3906.628	Fe	10	4308.081sG	Fe	6
3753.732	Fe–Ti	6d?	3920.410	Fe	10	4325.939s	Fe	8
3758.375s	Fe	15	3923.054	Fe	12d?	4340.634Hγ	H	20N
3759.447	Ti	12d?	3928.075s	Fe	8	4376.107s	Fe	6
3760.196	Fe	5	3930.450	Fe	8	4383.720s	Fe	15
3761.464	Ti	7	3933.523	–	8N	4404.927s	Fe	10
3763.945s	Fe	10	3933.825sK	Ca	1000	4415.293s	Fe	8
3765.689	Fe	6	3934.108	Co, V–Cr	8N	4442.510	Fe	6
3767.341s	Fe	8	3944.160s	Al	15	4447.892s	Fe	6
3775.717	Ni	7	3956.819	Fe	6	4494.738s	Fe	6
3783.674s	Ni	6	3957.177s	Fe–Ca	7d?	4528.798	Fe	8
3788.046s	Fe	9	3961.674s	Al	20	4534.139	Ti–Co	6
3795.147s	Fe	8	3968.350	–, Zr	6N	4549.808	Ti–Co	6d?
3798.655s	Fe	6	3968.625sH	Ca	700	4554.211s	Ba	8
3799.693s	Fe	7	3968.886	–	6N	4572.156s	Ti–	6
3805.486s	Fe	6	3969.413	Fe	10	4603.126	Fe	6
3806.865	Mn–Fe	8d?	3974.904	Co–Fe	6d?	4629.521s	Ti–Co	6
3807.293	Ni	6	3977.891s	Fe	6	4679.027s	Fe	6
3807.681	V–Fe	6	3986.903s	–	6	4703.177s	Mg	10
3814.698	–	8	4005.408	Fe	7	4714.599s	Ni	6
3815.987s	Fe	15	4030.918s	Mn	10d?	4736.963	Fe	6
3820.586sL	Fe–C	25	4033.224s	Mn	8d?	4754.225s	Mn	7
3824.591	Fe	6	4034.644s	Mn	6d	4783.613s	Mn	6

Corrections to reduce Rowland's wave-lengths to Fabry and Buisson's system (the accepted standard, 1908). Temperature 15° C, pressure 760 mm.

Wave-length	3600.	3700.	3800.	3900.	4000.	4100.	4200.	4300.	4400.	4500.	4600.	4700.	4800.
Correction	—.155	—.140	—.141	—.144	—.148	—.152	—.156	—.161	—.167	—.172	—.176	—.179	—.179.

TABLE 152 (*continued*).

STANDARD SOLAR WAVE-LENGTHS. ROWLAND'S VALUES.

Wave-length.	Substance.	Intensity.	Wave-length.	Substance.	Intensity.	Wave-length.	Substance.	Intensity.
4861.527sF	H	30	5948.765s	Si	6	6563.045sC	H	40
4890.948s	Fe	6	5985.040s	Fe	6	6593.161s	Fe	6
4891.683	Fe	8	6003.239s	Fe	6	6867.457sB	A(O)	6d?
4919.174s	Fe	6	6008.785s	Fe	6	6868.336 }s	A(O)	6
4920.685	Fe	10	6013.715s	Mn	6	6868.478 }	A(O)	6
4957.785s	Fe	8	6016.861s	Mn	6	6869.142s	A(O)	7
5050.008s	Fe	6	6022.016s	Mn	6	6869.353s	A(O)	6
5167.497sb_4	Mg	15	6024.281s	Fe	7	6870.116 }s	A(O)	7 }d
5171.778s	Fe	6	6065.709s	Fe	7	6870.249 }	A(O)	7 }
5172.856sb_2	Mg	20	6102.392s	Fe	6	6871.180s	A(O)	8
5183.791sb_1	Mg	30	6102.937s	Ca	9	6871.532s	A(O)	10
5233.122s	Fe	7	6108.334s	Ni	6	6872.486s	A(O)	11
5266.738s	Fe	6	6122.434s	Ca	10	6873.080s	A(O)	12
5269.723sE	Fe	8d?	6136.829s	Fe	8	6874.037s	A(O)	12
5283.802s	Fe	6	6137.915	Fe	7	6874.899s	A(O)	13
5324.373s	Fe	7	6141.938s	Fe, Ba	7	6875.830s	A(O)	13
5328.236	Fe	8d?	6155.350	–	7	6876.958s	A(O)	13
5340.121	Fe	6	6162.390s	Ca	15	6877.882s	A(O)	12
5341.213	Fe	7	6169.249s	Ca	6	6879.288s	A(O)	12
5367.669s	Fe	6	6169.778s	Ca	7	6880.172s	A(O)	6
5370.166s	Fe	6	6170.730	Fe–Ni	6	6884.076s	A(O)	10
5383.578s	Fe	6	6191.393s	Ni	6	6886.000s	A(O)	11
5397.344s	Fe	7d?	6191.779s	Fe	9	6886.990s	A(O)	12
5405.989s	Fe	6	6200.527s	Fe	6	6889.192s	A(O)	13
5424.290s	Fe	6	6213.644s	Fe	6	6890.151s	A(O)	14
5429.911	Fe	6d?	6219.494s	Fe	6	6892.618s	A(O)	14
5447.130s	Fe	6d?	6230.943s	V–Fe	8	6893.560s	A(O)	15
5528.641s	Mg	8	6246.535s	Fe	8	6896.289s	A(O)	14
5569.848	Fe	6	6252.773s	–Fe	7	6897.208s	A(O)	15
5573.075	Fe	6	6256.572s	Ni–Fe	6	6900.199s	A(O)	14
5586.991	Fe	7	6301.718	Fe	7	6901.117s	A(O)	15
5588.985s	Ca	6	6318.239	Fe	6	6904.362s	A(O)	14
5615.877s	Fe	6	6335.554	Fe	6	6905.271s	A(O)	14
5688.436s	Na	6	6337.048	Fe	7	6908.783s	A(O)	13
5711.313s	Mg	6	6358.898	Fe	6	6909.676s	A(O)	13
5763.218s	Fe	6	6393.820s	Fe	7	6913.448s	A(O)	11
5857.674s	Ca	8	6400.217s	Fe	8	6914.337s	A(O)	11
5862.582s	Fe	6	6411.865s	Fe	7	6918.370s	A(O)	9
5890.186sD_2	Na	30	6421.570s	Fe	7	6919.250s	A(O)	9
5896.155 D_1	Na	20	6439.293s	Ca	8	6923.553s	A(O)	9
5901.682s	A(wv)	6	6450.033s	Ca	6	6924.427s	A(O)	9
5914.430s	–, A(wv)	6	6494.004s	Ca	6	7191.755	A, –	6N
5919.860s	A(wv)	7	6495.213	Fe	8	7206.692	–, A	6
5930.406s	Fe	6	6546.479s	Ti–Fe	6			

Corrections to reduce Rowland's wave-lengths to Fabry and Buisson's system (the accepted standard, 1908); temperature 15° C, pressure 760 mm.:

Wave-length	4800.	4900.	5000.	5100.	5200.	5300.	5400.	5500.	5600.	5700.	5800.
Correction	—.179	—.176	—.173	—.170	—.166	—.172	—.212	—.217	—.218	—.213	—.209

Wave-length	5800.	5900.	6000.	6100.	6200.	6300.	6400.	6500.	6600.	6700.	6800.
Correction	—.209	—.209	—.213	—.214	—.213	—.210	—.209	—.210.			

TABLE 153.

STANDARD WAVE-LENGTHS. KAYSER'S IRON (ARC) LINES.

r = easily reversible.

Wave-length.	Intensity.	Correction.*	Wave-length.	Intensity.	Correction.*	Wave-length.	Intensity.	Correction.*	Wave-length.	Intensity.	Correction.*
2327.468	3		2518.198	8r		2742.506	10r		2973.254	8r	
31.384	3		22.950	20r		44.163	8r		73.366	5r	
32.869	3		23.754	4r		44.624	4r		81.565	7r	
38.073	1		27.525	10r		45.177	5r		83.690	10r	
43.567	3		29.223	8r		46.580	4r		87.410	4	—.117
48.196	2		33.911	4		47.080	5r		90.511	4	
48.380	2		35.699	6r		50.238	10r		94.554	10r	
54.969	2		37.263	4r		55.834	5r		2999.630	8r	
59.187	3		41.064	8r		56.412	4r		3001.068	10r	
60.079	2		44.016	4r		57.413	4r		07.262	2	
60.373	2		46.072	10r		61.883	5r		07.409	2r	
64.904	2		49.708	8r		62.125	5r		08.254	8r	
66.678	2		56.404	2		68.621	5r		09.690	4r	
68.670	2		56.963	2		72.205	8r		16.043	3	
70.588	2		62.619	5	—.078	78.327	6r	—.102	16.305	3	
73.813	3r	—.076	67.001	4		78.946	2		17.747	8r	
75.273	3		75.445	3		81.936	3		20.619	4r	
80.840	4		78.012	3		88.207	10r		20.764	10r	
82.114	7r		84.623	5r		91.989	3		21.194	10r	
84.473	3		85.964	3		2797.877	2		25.960	8r	
88.711	2		88.102	5r	—.086	2804.622	5r		31.332	4	
91.563	2		98.456	5r		07.088	5r		31.753	4r	
95.709	5r		99.483	5r		13.391	8r	—.101	37.505	10r	
2399.322	5r		2599.663	4r		17.612	3		41.753	3	
2404.519	3		2606.920	3r		23.382	5r		41.860	3	
04.969	5r		07.155	3r		25.660	6r		47.719	10r	
06.742	5r		11.963	5r		25.803	4r		51.179	3	
10.601	5r		13.914	4r		32.543	8r		57.562	8r	
11.152	4r		17.706	4r		35.562	4r		59.202	10r	
13.393	4r	—.083	18.108	2r		38.231	3r		67.363	8r	
24.231	3		23.627	5r		43.742	3r		68.286	3	
31.126	2		25.754	5r		44.083	8r		75.850	6r	—.125
35.234	(Si)	—.075	28.383	5r	—.087	51.910	5r	—.110	80.110	2	
39.834	4r		31.139	5r		59.007	3		83.853	5r	
40.201	4r		35.899	3r		63.973	3		91.687	3	
42.658	4r		44.085	3r		67.679	3		95.013	2	
47.808	4r		47.649	3		69.418	5r		3095.384	2	
53.568	2		51.800	2		74.284	5r	—.108	3100.057	4r	
57.686	5r		56.232	3		77.414	3		00.418	4r	
62.279	4r		66.897	3r		83.840	3		00.778	4r	
62.740	10r		73.315	2		90.000	3r		12.183	2	
65.244	5r		79.148	8r	—.083	94.617	3		16.747	3	
68.974	4r		80.544	3		2899.531	3		25.770	3	—.109
72.436	4r		89.302	8r		2901.496	3		32.627	5r	
72.976	10r		90.153	2		07.630	3		40.503	3u	
74.906	4r		92.710	2		12.273	8r	—.116	44.096	3u	
78.657	C		2699.193	3		18.144	3		51.460	3u	
79.872	10r		2706.672	4r		23.409	5		57.157	4	
83.361	20r		08.663	2		25.479	3		60.764	3	
83.618	3r		14.503	5	—.084	29.119	8r		65.129	3	
84.280	8r		18.530	4r		37.030	10r		71.473	3	
88.232	10r		19.121	10r		41.462	8r	—.115	75.556	7	—.109
89.844	8r		20.997	10r		44.519	3		78.122	5	
90.737	10r		23.671	8r		47.996	9r		80.339	7	
91.249	10r		25.024	4r		48.557	4		85.015	3	
93.331	7r		33.978	8r		54.061	9r		88.947	5	
2496.625	4r		35.566	8r		57.484	9r		91.778	5	
2501.228	8r		37.407	10r		65.379	7r		92.921	8	
07.991	4r		39.639	8r	—.089	67.019	10r		93.423	8	
2510.927	8r		2742.349	5r		2970.227	10r		3199.638	7	

Taken from Kayser's Handbuch der Spectroscopie.

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* For reducing to Fabry and Buisson's system of wave-lengths see Table 149 (the accepted standard, 1908); temperature 15° C, pressure 760 mm.

STANDARD WAVE-LENGTHS. KAYSER'S IRON (ARC) LINES.

r = easily reversible.

Wave-length.	Intensity.	Correction.*	Wave-length.	Intensity.	Correction.*	Wave-length.	Intensity.	Correction.*	Wave-length.	Intensity.	Correction.*
3200.595	7		3490.721	6r		3790.242	5		4107.646	5	
05.515	8		3497.989	5r		95.149	8r		14.608	4	
10.953	5		3506.650	3		3798.658	6r		18.709	8	—.157
14.158	10		08.627	2		3801.822	6r		37.156	6	
19.701	5		08.663	2		06.847	3u		44.033	10u	
19.935	5		13.974	5r	—.154	13.202	5		54.662	4	
22.187	10r		21.415	5r		15.987	8r		71.069	4	
25.905	10r	—.115	26.196	4r		20.573	9r		75.799	5	
31.091	8		26.822	4		24.591	6r		81.918	5	
34.745	8		29.960	3		26.028	8r		87.221	8	
39.564	8		40.287	2		27.967	7r		91.611	8	—.170
44.308	5		58.672	5r		34.370	8r		4199.256	6	
48.333	5		65.535	8r		40.586	7r		4202.195	8	
51.357	5		70.257	8r		41.194	8r		10.521	5	
57.724	3		81.348	7r		50.114	8r		19.523	5	
62.413	2		85.478	4r		56.515	6r		22.387	5	
65.746	8		87.137	4r		60.054	10r		27.606	6	
71.129	5	—.126	94.767	4u		65.670	6ru	—.144	33.771	7	—.146
80.386	5		3599.781	2		72.640	4r		36.118	8	
84.720	3		3605.619	4		78.166	6r		45.423	5	
86.884	7		06.836	4	—.155	78.722	4		47.604	5	
3292.721	5		12.242	2		86.426	6r		50.299	8	
3306.106	7		17.934	5		87.193	5r		50.948	8	
06.479	7		18.918	8r		95.801	5r		60.656	9	
14.868	5		22.158	5		3899.853	5r		71.333	7	
17.251	2		30.506	3		3903.097	6r		71.933	10r	
28.992	5		31.617	6r		06.624	6	—.143	82.567	7	—.160
37.793	4		32.195	5		09.980	3		85.614	4	
42.034	3		40.541	5	—.150	13.784	3		91.631	3	
48.056	4		47.997	7r		20.404	6r		94.290	6r	
55.355	4		50.429	3		28.073	5r		4299.420	6r	
66.917	3		51.615	5		41.032	4		4308.072	7r	
67.675	5		55.625	3		45.269	2		09.542	4	
78.814	5r		59.673	5		48.927	4		15.255	6	—.166
80.242	4		69.674	5		56.610	3		25.941	8	
84.113	4		76.461	3		56.823	5		37.219	6	
89.882	2		80.062	4r		66.219	3		46.739	3	
94.721	3		83.205	3		69.411	6r		52.910	5	—.169
3397.117	3		87.609	4r		77.892	6	—.147	58.689	3	
3402.392	4		3695.202	3		84.112	4		67.759	5	
06.578	2		3702.180	2		86.330	4		69.954	5	
06.938	4		05.714	4r		96.147	3		76.104	6	
13.275	5		09.395	5r		3998.211	3		83.724	8r	
24.430	5r		20.083	10r		4007.429	3		4391.137	4	
27.263	4		22.710	6r		17.303	2		4404.929	8	
40.762	9r		27.769	5r		22.029	5	—.157	15.301	8	
41.138	8r		33.470	5r		30.670	3		27.490	6	—.176
44.025	7r		35.016	9r		32.796	2		30.801	5	
45.301	5	—.146	37.278	8r		44.776	2		42.522	6	
50.484	4		43.510	6r		45.978	10r		47.907	6	
58.454	3		45.710	7r		55.706	3		54.572	4	
60.067	4		48.409	7r		62.605	5		61.838	5	
66.006	5r		49.634	8r		63.755	10r		66.737	6	—.183
71.413	3		58.381	8r		68.138	5		69.566	6	
71.497	3		63.940	8r		71.901	8r		76.207	6	
75.600	6r		67.339	7r		79.999	3		84.420	5	
76.850	6r		76.606	3		84.666	5		89.929	4	
83.159	3		78.670	2		96.135	5		4494.755	6	—.183
3485.490	3	—.146	3788.031	5		4098.346	5				

Taken from Kayser's Handbuch der Spectroscopie.

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* For reducing to Fabry and Buisson's system of wave-lengths see Table 149 (the accepted standard, 1908); temperature 15° C, pressure 760 mm.

TABLE 154.

WAVE-LENGTHS OF FRAUNHOFER LINES.

For convenience of reference the values of the wave-lengths corresponding to the Fraunhofer lines usually designated by the letters in the column headed "index letters," are here tabulated separately. The values are in ten millionths of a millimetre, on the supposition that the D line value is 5896.155. The table is for the most part taken from Rowland's table of standard wave-lengths.

Index Letter.	Line due to —	Wave-length in centimetres × 10^8.	Index Letter.	Line due to—	Wave-length in centimetres × 10^8.
A	O	7621.28*	G	Fe	4308.081
	O	7594.06*		Ca	4307.907
a	-	7164.725	g	Ca	4226.904
B	O	6870.182 †	h or H_δ	H	4102.000
C or H_α	H	6563.045	H	Ca	3968.625
α	O	6278.303 ‡	K	Ca	3933.825
D_1	Na	5896.155	L	Fe	3820.586
D_2	Na	5890.186	M	Fe	3727.778
D_3	He	5875.985	N	Fe	3581.349
E_1	Fe	5270.558	O	Fe	3441.155
	Ca	5270.438	P	Fe	3361.327
E_2	Fe	5269.723	Q	Fe	3286.898
b_1	Mg	5183.791	R	Ca	3181.387
b_2	Mg	5172.856		Ca	3179.453
b_3	Fe	5169.220	S_1 S_2	Fe	3100.787
	Fe	5169.069		Fe	3100.430
b_4	Fe	5167.678		Fe	3100.046
	Mg	5167.497	s	Fe	3047.725
F or H_β	H	4861.527	T	Fe	3020.76
d	Fe	4383.721	t	Fe	2994.53
G′ or H_γ	H	4340.634	U	Fe	2947.99
f	Fe	4325.939			

* The two lines here given for A are stated by Rowland to be: the first, a line "beginning at the head of A, outside edge;" the second, a "single line beginning at the tail of A."

† The principal line in the head of B.

‡ Chief line in the α group.

See Table 152, Rowland's Solar Wave-lengths (foot of page) for correction to reduce these values to Fabry-Buisson system of wave-lengths.

TABLE 155.

PHOTOMETRIC STANDARDS

No primary photometric standard has been generally adopted by the various governments. In Germany the Hefner lamp is most used; in England the Pentane lamp and sperm candles are used; in France the Carcel lamp is preferred; in America the Pentane and Hefner lamps are used to some extent, but candles are more largely employed in gas photometry. For the photometry of electric lamps, and generally in accurate photometric work, electric lamps, standardized at a national standardizing institution, are commonly employed.

The "International candle" is the name recently employed to designate the value of the candle as maintained by coöperative effort between the national laboratories of England, France, and America; and the value of various photometric units in terms of this international candle is given in the following table (taken from Circular No. 15 of the Bureau of Standards).

1 International Candle = 1 Pentane Candle.
1 International Candle = 1 Bougie Decimale.
1 International Candle = 1 American Candle.
1 International Candle = 1.11 Hefner Unit.
1 International Candle = 0.104 Carcel Unit.

Therefore 1 Hefner Unit = 0.90 International Candle.

The values of the flame standards most commonly used are as follows:

1. Standard Pentane Lamp, burning pentane	10.0 candles.
2. Standard Hefner Lamp, burning amyl acetate	0.9 candles.
3. Standard Carcel Lamp, burning colza oil	9.6 candles.
4. Standard English Sperm Candle, approximately	1.0 candles.

Slight differences in candle power are found in different lamps, even when made as accurately as possible to the same specifications. Hence these so-called primary standards should be themselves standardized.

SENSITIVENESS OF THE EYE TO RADIATION.

(Compiled from Nutting, Bulletin of the Bureau of Standards.)

Radiation is easily visible to most eyes from 0.330μ in the violet to 0.770μ in the red. At low intensities approaching threshold values (rod vision) the maximum of spectral sensibility lies in the green at about 0.510μ for 90% of all persons. At higher intensities with the establishment of cone vision the maximum shifts towards the yellow at least as far as 0.560μ.

TABLE 156. — Variation of the Sensitiveness of the Eye with the Wave-length at Low Intensities (near Threshold Values). König.

λ	.410	.430	.450	.470	.490	.510	.530	.550	.570	.590	.610
Mean sensitiveness	0.02	0.06	0.23	0.49	0.81	1.00	0.81	0.49	0.22	0.077	0.026

TABLE 157. — Variation of Sensitiveness to Radiation of Greater Intensities.

The sensibility is approximately proportional to the intensity over a wide range. The ratio of optical- to radiation-intensity increases more rapidly for the red than for the blue or green (Purkinje phenomenon).

The intensity is given for the spectrum at 0.535μ (green).

Intensity (metre-candles) =	.00024	.00225	.0360	.575	2.30	9.22	36.9	147.6	590.4
Ratio to preceding step =	-	9.38	16	16	4	4	4	4	4
Wave-length, λ.	Sensitiveness.								
0.430μ	.081	.093	.127	.128	.114	.114	–	–	–
.450	.33	.30	.29	.31	.23	.175	.16	–	–
.470	.63	.59	.54	.58	.51	.29	.26	.23	–
.490	.96	(.89)	(.76)	(.89)	(.83)	.50	.45	.38	.35
.505	1.00	1.00	1.00	1.00	.99	(.76)	.66	.61	.54
.520	.88	.86	.86	.94	.99	(.85)	.85	.85	.82
.535	.61	.62	.63	.72	.91	(.98)	.98	.99	.98
.555	.26	.30	.34	.41	.62	.84	.93	.97	.98
.575	.074	.102	.122	.168	(.39)	(.63)	(.76)	(.82)	(.84)
.590	.025	.034	.054	.091	.27	.49	.61	.68	.69
.605	.008	.012	.024	.056	.173	.35	(.45)	.54	.55
.625	.004	.004	.011	.027	.098	.20	.27	.35	.35
.650	.000	.000	.003	.007	.025	.060	.085	.122	.133
.670	.000	.000	.001	.002	.007	.017	.025	.030	.030
λ, maximum sensitiveness	.503	.504	.504	.508	.513	.530	.541	.543	.544

TABLE 158. — Sensibility to Small Differences in Intensity measured as a Fraction of the Whole.

λ = I_0 in m. c. =	.670 0.060	.605 0.0056	.575 0.0029	.505 0.00017	.470 0.00012	.430 0.00012	White 0.00072
I	δI : I König's data, measures from one normal person only.						
1,000,000					–	–	.036
200,000	-	.042		–	–	–	.027
100,000		.024	.032	–	–	–	.019
50,000	.021	.025	.026	–		–	.017
20,000	.016	.018	.020	.019	–	–	.017
10,000	.016	.016	.018	.018		–	.018
5,000	.018	.016	.017	.016		–	.018
2,000	.016	.018	.018	.017	.018	–	.018
1,000	.017	.020	.018	.018	.017	.018	.018
500	.020	.021	.018	.019	.018	.021	.019
200	.022	.022	.022	.022	.021	.024	.022
100	.029	.028	.027	.024	.022	.025	.030
50	.038	.038	.032	.025	.025	.027	.032
10	.065	.061	.058	.036	.037	.040	.048
5	.092	.103	.089	.049	.046	.049	.059
1	.258	.212	.170	.080	.088	.074	.123
0.5	.376	.276	.21	.091	.096	.097	.188
0.10	–	–	.40	.133	.138	.137	.377
0.05	-	-	–	.183	.185	.154	.484
0.01				.271	.289	.249	–
0.005				.325	.300	.312	

The sensibility to small differences in intensity is independent of the intensity (Fechner's law). About 0.016 for moderate intensities. Greater for extreme values.

It is independent of wave-length, extremes excepted (König's law).

Sensibility to slight differences in wave-length has two pronounced maxima (one in the yellow, one in the green) and two slight maxima (extreme blue, extreme red).

The visual sensation as a function of the time approaches a constant value with the lapse of time. With blue light there seems to be a pronounced maximum at 0.07 sec., with red a slight one at 0.12 seconds, with green the sensation rises steadily to its final value. For lower intensities these max. occur later.

An intensity of 500 metre-candles is about that on a horizontal plane on a cloudy day.

TABLE 159. — Solar Energy and its Absorption by the Earth's Atmosphere.

The following values depend upon the formula $e_m = e_0 a^m$, where e_m is the observed value of the solar energy after transmission through a mass of air, m; m = unity when the sun is in the zenith, and approximately = sec. zenith distance for other positions of the sun. e_0 = the energy which would have been observed had there been no absorbing atmosphere; a is the amount transmitted when the sun is in the zenith or when $m = 1$.

Wave-length. μ	Transmission coefficient, a.				Intensity of Solar Energy.										
	Wash-ington.	Mount Wilson.	Mount Whitney.	One mile nearer Earth.		Mt Whitney.	Mount Wilson.				Washington.				
					$m=0$	$m=1$	$m=1$	2	4	6	$m=1$	2	3	4	6
0.30	–	(.485)	.522	–	95	50	46	22	05	1.2	–	–	–	–	–
.32	–	(.562)	.615	–	195	120	110	62	19	6.2	–	–	–	–	–
.34	–	.626	.687	–	305	210	191	120	47	18	–	–	–	–	–
.36	–	.676	.745	–	420	313	284	192	88	40	–	–	–	–	–
.38	(.360)	.713	.788	.505	501	394	357	255	129	66	180	65	23	8	1.1
.40	.542	.746	.821	.725	580	476	433	323	180	100	314	171	92	50	15
.46	.653	.816	.879	.800	730	642	596	486	323	215	477	311	203	133	57
.50	.704	.850	.902	.829	685	618	582	495	358	258	482	340	239	169	84
.60	.762	.884	.942	.862	590	556	522	461	360	281	450	343	261	199	116
.70	.838	.937	.966	.894	454	439	425	399	350	307	380	319	267	224	157
.80	.867	.955	.981	.909	342	336	327	312	285	260	297	257	223	193	145
1.00	.901	.968	.991	.930	190	188	184	178	167	156	171	154	139	125	102
1.50	.923	.977*	.956	.950	82	78	80*	78*	75*	71*	76	70	64	60	51
2.00	.909	.969*	.925	.932	30	28	29*	28*	26*	25*	27	25	23	20	17

* These may be too high because of the usual increased humidity towards noon at Mount Wilson.

TABLE 160. — Solar Constant.

Solar constant (amount of energy falling at normal incidence on one square centimetre per minute on body at earth's mean distance) = 1.92 small calories. Mount Wilson and Mount Whitney observations.

Computed effective temperature of the sun: Goldhammer's method (Ann. der Phys. (4) 25, 905, 1908), 6200° Absolute; from form of black body curves, 6000 to 7000°; from λ max. = 2930, 6370°; from Total Radiation, $J = 76.8 \times 10^{-12}$, 5830°.

TABLE 161. — Distribution of Brightness (Radiation) over the Solar Disk.

(These observations extend over only a small portion of a sun-spot cycle.)

	Wave-length.	μ 0.323	μ 0.386	μ 0.433	μ 0.456	μ 0.481	μ 0.501	μ 0.534	μ 0.604	μ 0.670	μ 0.699	μ 0.866	μ 1.031	μ 1.225	μ 1.655	μ 2.097
Fraction Radius.	0.00	144	338	456	515	511	489	463	399	333	307	174	111	77.6	39.5	14.0
	0.40	128	312	423	486	483	463	440	382	320	295	169	108	75.7	38.9	13.8
	0.55	120	289	395	455	456	437	417	365	308	284	163	105.5	73.8	38.2	13.6
	0.65	112	267	368	428	430	414	396	348	295	273	159	103	72.2	37.6	13.4
	0.75	99	240	333	390	394	380	366	326	281	258	152	99	69.8	36.7	13.1
	0.825	86	214	296	351	358	347	337	304	262	243	145	94.5	67.1	35.7	12.8
	0.875	76	188	266	317	324	323	312	284	247	229	138	90.5	64.7	34.7	12.5
	0.92	64	163	233	277	290	286	281	259	227	212	130	86	61.6	33.6	12.2
	0.95	49	141	205	242	255	254	254	237	210	195	122	81	58.7	32.3	11.7

TABLE 162. — Relative Distribution in Normal Spectrum of Sun and Sky-light at Mount Wilson.

Zenith distance about 50°.

	μ	μ	μ	μ	μ	μ	C	D	b	F
Place in Spectrum	0.422	0.457	0.491	0.566	0.614	0.660				
Intensity Sunlight	186	232	227	211	191	166				
Intensity Sky-light	1194	986	701	395	231	174				
Ratio at Mount Wilson	642	425	309	187	121	105	25	35	60	77
Ratio computed by Rayleigh	–	–	–	–	–	–	25	40	63	80
Ratio observed by Rayleigh	–	–	–	–	–	–	25	41	71	90

Derived from vol. II and unpublished data of the Astrophysical Observatory of the Smithsonian Institution, Abbot and Fowle, Astrophysical Journal, 29, 1909, and Schwartzchild and Villiger, same Journal, 23, 1906.

TABLE 163. — Glasses Made by Schott and Gen, Jena.

The following constants are for glasses made by Schott and Gen, Jena: n_A, n_C, n_D, n_F, n_G, are the indices of refraction in air for A=0.7682μ, C=0.6563μ, D=0.5893, F=0.4861, G′=0.4341. $v=(n_D-1)/(n_F-n_C)$. Ultra-violet indices: Simon, Wied. Ann. 53, 1894. Infra-red: Rubens, Wied. Ann. 45, 1892. Table is revised from Landolt, Börnstein and Meyerhoffer, Kayser, Handbuch der Spectroscopie, and Schott and Gen's list No. 751, 1909. See also Hovestadt's "Jena Glass."

Catalogue Type =		O 546	O 381	O 184	O 102	O 165	S 57
Designation =		Zinc-Crown.	Higher Dispersion Crown.	Light Silicate Flint.	Heavy Silicate Flint.	Heavy Silicate Flint.	Heaviest Silicate Flint.
Melting Number =		1092	1151	451	469	500	163
v =		60.7	51.8	41.1	33.7	27.6	22.2
Kind of Light and Wave-length.	Cd 0.2763μ	1.56759		-	-	-	-
	Cd .2837	1.56372	-	-	-	-	-
	Cd .2980	1.55723	1.57093	1.65397	-	-	-
	Cd .3403	1.54369	1.55262	1.63320	1.71968	1.85487	-
	Cd .3610	1.53897	1.54664	1.61388	1.70536	1.83263	-
	H .4340μ	1.52788	1.53312	1.59355	1.67561	1.78800	1.94493
	H .4861	1.52299	1.52715	1.58515	1.66367	1.77091	1.91890
	Na .5893	1.51698	1.52002	1.57524	1.64985	1.75130	1.88995
	H .6563	1.51446	1.51712	1.57119	1.64440	1.74368	1.87893
	K .7682	1.51143	1.51368	1.56669	1.63820	1.73530	1.86702
	.800μ	1.5103	1.5131	1.5659	1.6373	1.7339	1.8650
	1.200	1.5048	1.5069	1.5585	1.6277	1.7215	1.8481
	1.600	1.5008	1.5024	1.5535	1.6217	1.7151	1.8396
	2.000	1.4967	1.4973	1.5487	1.6171	1.7104	1.8316
	2.400	-	-	1.5440	1.6131	-	1.8286

Percentage composition of the above glasses:

O 546, SiO_2, 65.4; K_2O, 15.0; Na_2O, 5.0; BaO, 9.6; ZnO, 2.0; Mn_2O_3, 0.1; As_2O_3, 0.4; B_2O_3, 2.5.
O 381, SiO_2, 68.7; PbO, 13.3; Na_2O, 15.7; ZnO, 2.0; MnO_2, 0.1; As_2O_5, 0.2.
O 184, SiO_2, 53.7; PbO, 36.0; K_2O, 8.3; Na_2O, 1.0; Mn_2O_3, 0.06; As_2O_3, 0.3.
O 102, SiO_2, 40.0; PbO, 52.6; K_2O, 6.5; Na_2O, 0.5; Mn_2O_3, 0.09; As_2O_5, 0.3.
O 165, SiO_2, 29.26; PbO, 67.5; K_2O, 3.0; Mn_2O_3, 0.04; As_2O_3, 0.2.
S 57, SiO_2, 21.9; PbO, 78.0; As_2O_5, 0.1.

TABLE 164. — Jena Glasses.

No. and Type of Jena Glass.	n_D for D	n_F-n_C	$v=\frac{n_D-1}{n_F-n_C}$	n_D-n_A	n_F-n_D	$n_{G'}-n_F$	Specific Weight.
O 225 Light phosphate crown	1.5159	.00737	70.0	.00485	.00515	.00407	2.58
O 802 Boro-silicate crown	1.4967	0765	64.9	0504	0534	0423	2.38
UV 3199 Ultra-violet crown	1.5035	0781	64.4	0514	0546	0432	2.41
O 227 Barium-silicate crown	1.5399	0909	59.4	0582	0639	0514	2.73
O 114 Soft-silicate crown	1.5151	0910	56.6	0577	0642	0521	2.55
O 608 High-dispersion crown	1.5149	0943	54.6	0595	0666	0543	2.60
UV 3248 Ultra-violet flint	1.5332	0964	55.4	0611	0680	0553	2.75
O 381 High-dispersion crown	1.5262	1026	51.3	0644	0727	0596	2.70
O 602 Baryt light flint	1.5676	1072	53.0	0675	0759	0618	3.12
S 389 Borate flint	1.5686	1102	51.6	0712	0775	0629	2.83
O 726 Extra light flint	1.5398	1142	47.3	0711	0810	0669	2.87
O 154 Ordinary light flint	1.5710	1327	43.0	0819	0943	0791	3.16
O 184 " " "	1.5900	1438	41.1	0882	1022	0861	3.28
O 748 Baryt flint	1.6235	1599	39.1	9965	1142	0965	3.67
O 102 Heavy flint	1.6489	1919	33.8	1152	1372	1180	3.87
O 41 " "	1.7174	2434	29.5	1439	1749	1521	4.49
O 165 " "	1.7541	2743	27.5	1607	1974	1730	4.78
S 386 Heavy flint	1.9170	4289	21.4	2451	3109	2808	6.01
S 57 Heaviest flint	1.9626	4882	19.7	2767	3547	3252	6.33

TABLE 165. — Change of Indices of Refraction for 1° C in Units of the Fifth Decimal Place.

No. and Designation.	Mean Temp.	C	D	F	G′	$\frac{-\Delta n}{n}100$
S 57 Heavy silicate flint	58.8°	1.204	1.447	2.090	2.810	0.0166
O 154 Light silicate flint	58.4	0.225	0.261	0.334	0.407	0.0078
O 327 Baryt flint light	58.3	—0.008	0.014	0.080	0.137	0.0079
O 225 Light phosphate crown	58.1	—0.202	—0.190	—0.168	—0.142	0.0049

Pulfrich, Wied. Ann. 45, p. 609, 1892.

TABLE 166.

INDEX OF REFRACTION.

Indices of Refraction for the various Alums.*

R	Density.	Temp. C°	Index of refraction for the Fraunhofer lines.							
			a	B	c	D	E	b	F	G
Aluminium Alums. $R\mathrm{Al(SO_4)_2+12H_2O}$.†										
Na	1.667	17–28	1.43492	1.43563	1.43653	1.43884	1.44185	1.44231	1.44412	1.44804
$NH_3(CH_3)$	1.568	7–17	.45013	.45062	.45177	.45410	.45691	.45749	.45941	.46363
K	1.735	14–15	.45226	.45303	.45398	.45645	.45934	.45996	.46181	.46609
Rb	1.852	7–21	.45232	.45328	.45417	.45660	.45955	.45999	.46192	.46618
Cs	1.961	15–25	.45437	.45517	.45618	.45856	.46141	.46203	.46386	.46821
NH_4	1.631	15–20	.45509	.45599	.45693	.45939	.46234	.46288	.46481	.46923
Tl	2.329	10–23	.49226	.49317	.49443	.49748	.50128	.50209	.50463	.51076
Indium Alums. $R\mathrm{In(SO_4)_2+12H_2O}$.†										
Rb	2.065	3–13	1.45942	1.46024	1.46126	1.46381	1.46694	1.46751	1.46955	1.47402
Cs	2.241	17–22	.46091	.46170	.46283	.46522	.46842	.46897	.47105	.47562
NH_4	2.011	17–21	.46193	.46259	.46352	.46636	.46953	.47015	.47234	.47750
Gallium Alums. $R\mathrm{Ga(SO_4)_2+12H_2O}$.†										
Cs	2.113	17–22	1.46047	1.46146	1.46243	1.46495	1.46785	1.46841	1.47034	1.47481
K	1.895	19–25	.46118	.46195	.46296	.46528	.46842	.46904	.47093	.47548
Rb	1.962	13–15	.46152	.46238	.46332	.46579	.46890	.46930	.47126	.47581
NH_4	1.777	15–21	.46390	.46485	.46575	.46835	.47146	.47204	.47412	.47864
Tl	2.477	18–20	.50112	.50228	.50349	.50665	.51057	.51131	.51387	.52007
Chrome Alums. $R\mathrm{Cr(SO_4)_2+12H_2O}$.†										
Cs	2.043	6–12	1.47627	1.47732	1.47836	1.48100	1.48434	1.48491	1.48723	1.49280
K	1.817	6–17	.47642	.47738	.47865	.48137	.48459	.48513	.48753	.49309
Rb	1.946	12–17	.47660	.47756	.47868	.48151	.48486	.48522	.48775	.49323
NH_4	1.719	7–18	.47911	.48014	.48125	.48418	.48744	.48794	.49040	.49594
Tl	2.386	9–25	.51692	.51798	.51923	.52280	.52704	.52787	.53082	.53808
Iron Alums. $R\mathrm{Fe(SO_4)_2+12H_2O}$.†										
K	1.806	7–11	1.47639	1.47706	1.47837	1.48169	1.48580	1.48670	1.48939	1.49605
Rb	1.916	7–20	.47700	.47770	.47894	.48234	.48654	.48712	.49003	.49700
Cs	2.061	20–24	.47825	.47921	.48042	.48378	.48797	.48867	.49136	.49838
NH_4	1.713	7–20	.47927	.48029	.48150	.48482	.48921	.48993	.49286	.49980
Tl	2.385	15–17	.51674	.51790	.51943	.52365	.52859	.52946	.53284	.54112

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* According to the experiments of Soret (Arch. d. Sc. Phys. Nat. Genève, 1884, 1888, and Comptes Rendus, 1885).

† *R* stands for the different bases given in the first column.

TABLE 167.

INDEX OF REFRACTION.

Index of Refraction of Metals and Metallic Oxides.

(a) Experiments of Kundt* by transmission of light through metallic prisms of small angle.

Name of substance.	Index of refraction for		
	Red.	White.	Blue.
Silver	–	0.27	–
Gold	0.38	0.58	1.00
Copper	0.45	0.65	0.95
Platinum	1.76	1.64	1.44
Iron	1.81	1.73	1.52
Nickel	2.17	2.01	1.85
Bismuth	2.61	2.26	2.13
Gold and gold oxide	1.04	–	1.25
" " "	0.89	0.99	1.33
" " " †	–	2.03	–
Bismuth oxide	–	1.91	–
Iron oxide	1.78	2.11	2.36
Nickel oxide	2.18	2.23	2.39
Copper oxide	2.63	2.84	3.18
Platinum and platinum oxide	3.31	3.29	2.90
" " "	4.99	4.82	4.40

(b) Experiments of Du Bois and Rubens by transmission of light through prisms of small angle.

The experiments were similar to those of Kundt, and were made with the same spectrometer. Somewhat greater accuracy is claimed for these results on account of some improvements introduced, mainly by Prof. Kundt, into the method of experiment. There still remains, however, a somewhat large chance of error.

Name of metal.	Index of refraction for light of the following color and wave-length.				
	Red (Li_α). $\lambda = 67.1$	"Red." $\lambda = 64.4$	Yellow (D). $\lambda = 58.9$	Blue (F). $\lambda = 48.6$	Violet (G). $\lambda = 43.1$‡
Nickel	2.04	1.93	1.84	1.71	1.54
Iron	3.12	3.06	2.72	2.43	2.05
Cobalt	3.22	3.10	2.76	2.39	2.10

(c) Experiments of Drude.

The following table gives the results of some of Drude's experiments.§ The index of refraction is derived in this case from the constants of elliptic polarization by reflection, and are for sodium light.

Metal.	Index of refraction.	Metal.	Index of refraction.
Aluminium	1.44	Mercury	1.73
Antimony	3.04	Nickel	1.79
Bismuth	1.90	Platinum	2.06
Cadmium	1.13	Silver	0.181
Copper	0.641	Steel	2.41
Gold	0.366	Tin, solid	1.48
Iron	2.36	" fluid	2.10
Lead	2.01	Zinc	2.12
Magnesium	0.37		

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* "Wied. Ann." vol. 34, and "Phil. Mag." (5) vol. 26.

† Nearly pure oxide.

‡ Wave-lengths λ are in millionths of a centimetre.

§ "Wied. Ann." vol. 39.

TABLE 168.—Index of Refraction of Rock Salt in Air.

$\lambda(\mu)$.	n.	Observer.	$\lambda(\mu)$.	n.	Observer.	$\lambda(\mu)$.	n.	Observer.
0.185409	1.89348	M	0.88396	1.534011	L	5.8932	1.516014	P
.204470	1.76964	"	.972298	1.532532	"	"	1.515553	L
.291368	1.61325	"	.98220	1.532435	P	6.4825	1.513628	P
.358702	1.57932	"	1.036758	1.531762	L	"	1.513467	L
.441587	1.55962	"	1.1786	1.530372	P	7.0718	1.511062	P
.486149	1.55338	"	"	1.530374	L	7.6611	1.508318	"
"	1.553406	L	1.555137	1.528211	"	7.9558	1.506804	"
"	1.553399	P	1.7680	1.527440	P	8.8398	1.502035	"
.58902	1.544340	L	"	1.527441	L	10.0184	1.494722	"
.58932	1.544313	P	2.073516	1.526554	"	11.7864	1.481816	"
.656304	1.540672	P	2.35728	1.525863	P	12.9650	1.471720	"
"	1.540702	L	"	1.525849	L	14.1436	1.460547	"
.706548	1.538633	P	2.9466	1.524534	P	14.7330	1.454404	"
.766529	1.536712	P	3.5359	1.523173	"	15.3223	1.447494	"
.76824	1.53666	M	4.1252	1.521648	P	15.9116	1.441032	"
.78576	1.536138	P	"	1.521625	L	20.57	1.3735	RN
.88396	1.534011	P	5.0092	1.518978	P	22.3	1.340	"

$$n^2=a^2+\frac{M_1}{\lambda^2-\lambda_1^2}+\frac{M_2}{\lambda^2-\lambda_2^2}-k\lambda^2-h\lambda^4 \text{ or }=b^2+\frac{M_1}{\lambda^2-\lambda_1^2}+\frac{M_2}{\lambda^2-\lambda_2^2}-\frac{M_3}{\lambda_3^2-\lambda^2}$$

where $a^2=2.330165$ $\lambda_2^2=0.02547414$ $b^2=5.680137$

$M_1=0.01278685$ $k=0.0009285837$ $M_3=12059.95$

$\lambda_1^2=0.0148500$ $h=0.000000286086$ $\lambda_3^2=3600.$ (P)

$M_2=0.005343924$

TABLE 168.—Change of Index of Refraction for 1° C in Units of the 5th Decimal Place.

0.202μ	+3.134	Mi	0.441μ	−3.425	Mi	C line	−3.749	Pl	0.760μ	−3.73	L
.210	+1.570	"	.508	−3.517	"	D "	−3.739	"	1.368	−3.88	L
.224	−0.187	"	.643	−3.636	"	F "	−3.648	"	1.88	−3.85	L
.298	−2.727	"				G′ "	−3.585	"	4.3	−3.82	L

L Annals of the Astrophysical Observatory of the Smithsonian Institution, Vol. I, 1900.
M Martens, Ann. d. Phys. 6, 1901, 8, 1902.
Mi Micheli, Ann. d. Phys. 7, 1902.
P Paschen, Wied. Ann. 26, 1908.
Pl Pulfrich, Wied. Ann. 45, 1892.
RN Rubens and Nichols, Wied. Ann. 60, 1897.

TABLE 170.—Index of Refraction of Silvine (Potassium Chloride) in Air.

$\lambda(\mu)$.	n	Observer.	$\lambda(\mu)$.	n.	Observer.	$\lambda(\mu)$.	n.	Observer.
0.185409	1.82710	M	1.1786	1.478311	P	8.2505	1.462726	P
.200090	1.71870	"	"	1.47824	W	"	1.46276	W
.21946	1.64745	"	1.7680	1.475890	P	8.8398	1.460858	P
.257317	1.58125	"	"	1.47589	W	"	1.46092	W
.281640	1.55836	"	2.35728	1.474751	P	10.0184	1.45672	P
.308227	1.54136	"	2.9466	1.473834	"	"	1.45673	W
.358702	1.52115	"	"	1.47394	W	11.786	1.44919	P
.394415	1.51219	"	3.5359	1.473049	P	"	1.44941	W
.467832	1.50044	"	"	1.47304	W	12.965	1.44346	P
.508606	1.49620	"	4.7146	1.471122	P	"	1.44385	W
.58932	1.490443	P	"	1.47129	W	14.144	1.43722	P
.67082	1.48669	M	5.3039	1.470013	P	15.912	1.42617	"
.78576	1.483282	P	"	1.47001	W	17.680	1.41403	"
.88398	1.481422	P	5.8932	1.468804	P	20.60	1.3882	RN
.98220	1.480084	"	"	1.46880	W	22.5	1.369	"

$$n^2=a^2+\frac{M_1}{\lambda^2-\lambda_1^2}+\frac{M_2}{\lambda^2-\lambda_2^2}-k\lambda^2-h\lambda^4 \text{ or }=b^2+\frac{M_1}{\lambda^2-\lambda_1^2}+\frac{M_2}{\lambda^2-\lambda_2^2}+\frac{M_3}{\lambda_3^2-\lambda^2}$$

$a^2=2.174967$ $\lambda_2^2=0.0255550$ $b^2=3.866619$

$M_1=0.008344206$ $k=0.000513495$ $M_3=5569.715$

$\lambda_1^2=0.0119082$ $h=0.000000167587$ $\lambda_3^2=3292.47$ (P)

$M_2=0.00698382$

W Weller, see Paschen's article. Other references as under Table 169, above.

TABLES 171-174.

INDEX OF REFRACTION.

TABLE 171. — Index of Refraction of Fluorite in Air.

λ (μ)	n	Observer	λ (μ)	n	Observer	λ (μ)	n	Observer.
0.1856	1.50940	S	1.4733	1.42641	P	4.1252	1.40855	P
.19881	1.49629	"	1.5715	1.42596	"	4.4199	1.40559	"
.21441	1.48462	"	1.6206	1.42582	"	4.7146	1.40238	"
.22645	1.47762	"	1.7680	1.42507	"	5.0092	1.39898	"
.25713	1.46476	"	1.9153	1.42437	"	5.3036	1.39529	"
.32525	1.44987	"	1.9644	1.42413	"	5.5985	1.39142	"
.34555	1.44697	"	2.0626	1.42359	"	5.8932	1.38719	"
.39681	1.44214	"	2.1608	1.42308	"	6.4825	1.37819	"
.48607	1.43713	P	2.2100	1.42288	"	7.0718	1.36805	"
.58930	1.43393	P	2.3573	1.42199	"	7.6612	1.35680	"
.65618	1.43257	S	2.5537	1.42088	"	8.2505	1.34444	"
.68671	1.43200	"	2.6519	1.42016	"	8.8398	1.33079	"
.71836	1.43157	"	2.7502	1.41971	"	9.4291	1.31612	"
.76040	1.43101	"	2.9466	1.41826	"	51.2	3.47	RA
.8840	1.42982	P	3.1430	1.41707	"	61.1	2.66	"
1.1786	1.42787	"	3.2413	1.41612	"	∞	2.63	S
1.3756	1.42690	"	3.5359	1.41379	"			
1.4733	1.42641	"	3.8306	1.41120	"			

References under Table 173.

$$n^2 = a^2 + \frac{M_1}{\lambda^2 - \lambda_1^2} - e\lambda^2 - f\lambda^4 \text{ or } = b^2 + \frac{M_2}{\lambda^2 - \lambda_v^2} + \frac{M_8}{\lambda^2 - \lambda_r^2}$$

where $a^2 = 2.03882$ $\quad f = 0.000002916$ $\quad M_8 = 5114.65$
$M_1 = 0.0062183$ $\quad b^2 = 6.09651$ $\quad \lambda_r^2 = 1260.56$
$\lambda_1^2 = 0.007706$ $\quad M_2 = 0.0061386$ $\quad \lambda_v = 0.0940\mu$
$e = 0.0031999$ $\quad \lambda_v^2 = 0.00884$ $\quad \lambda_r = 35.5\mu$ (P)

TABLE 172. — Change of Index of Refraction for 1° C in Units of the 5th Decimal Place.

C line, —1.220; D, —1.206; F, —1.170; G, —1.142. (Pl)

TABLE 173. — Index of Refraction of Iceland Spar ($CaCO_3$) in Air.

λ (μ)	n_o	n_e	Observer.	λ (μ)	n_o	n_e	Observer.	λ (μ)	n_o	n_e	Observer.
0.198	–	1.5780	M	0.508	1.6653	1.4896	M	0.991	1.6438	1.4802	C
.200	1.9028	1.5765	"	.533	1.6628	1.4884	"	1.229	1.6393	1.4787	"
.208	1.8673	1.5664	"	.589	1.6584	1.4864	"	1.307	1.6379	1.4783	"
.226	1.8130	1.5492	–	.643	1.6550	1.4849	"	1.497	1.6346	1.4774	"
.298	1.7230	1.5151	C	.656	1.6544	1.4846	"	1.682	1.6313	–	"
.340	1.7008	1.5056	M	.670	1.6537	1.4843	"	1.749	–	1.4764	"
.361	1.6932	1.5022	C	.760	1.6500	1.4826	–	1.849	1.6280	–	"
.410	1.6802	1.4964	–	.768	1.6497	1.4826	M	1.908	–	1.4757	"
.434	1.6755	1.4943	M	.801	1.6487	1.4822	C	2.172	1.6210	–	"
.486	1.6678	1.4907	"	.905	1.6458	1.4810	"	2.324	–	1.4739	"

C Carvallo, J. de Phys. (3), 9, 1900.
M Martens, Ann. der Phys. (4) 6, 1901, 8, 1902.
P Paschen, Wied. Ann. 56, 1895.
Pl Pulfrich, Wied. Ann 45, 1892.
RA Rubens-Aschkinass, Wied. Ann. 67, 1899.
S Starke, Wied. Ann. 60, 1897.

TABLE 174. — Index of Refraction of Nitroso-dimethyl-aniline. (Wood.)

λ	n	λ	n	λ	n	λ	n	λ	n
0.497	2.140	0.525	1.945	0.584	1.815	0.636	1.647	0.713	1.718
.500	2.114	.536	1.909	.602	1.796	.647	1.758	.730	1.713
.506	2.074	.546	1.879	.611	1.783	.659	1.750	.749	1.709
.508	2.025	.557	1.857	.620	1.778	.669	1.743	.763	1.697
.516	1.985	.569	1.834	.627	1.769	.696	1.723		

Nitroso-dimethyl-aniline has enormous dispersion in yellow and green, metallic absorption in violet. See Wood, Phil. Mag. 1903.

TABLE 175.

INDEX OF REFRACTION.

Index of Refraction of Quartz (SiO_2).

Wave-length.	Index Ordinary Ray.	Index Extraordinary Ray.	Temperature ° C.	Wave-length.	Index Ordinary Ray.	Index Extraordinary Ray.	Temperature ° C.
0.185	1.67582	1.68999	18	0.656	1.54189	1.55091	18
.193	.65997	.67343	"	.686	.54099	.54998	"
.198	.65090	.66397	"	.760	.53917	.54811	"
.206	.64038	.65300	"	1.160	.5329	Rubens.	–
.214	.63041	.64264	"	.969	.5216		–
.219	.62494	.63698	"	2.327	.5156		–
.231	.61399	.62560	"	.84	.5039		–
.257	.59622	.60712	"	3.18	.4944		–
.274	.58752	.59811	"	.63	.4799		–
.340	.56748	.57738	"	.96	.4679		–
.396	.55815	.56771	"	4.20	.4569		–
.410	.55650	.56600	"	5.0	.417		–
.486	.54968	.55896	"	6.45	.274		–
0.598	1.54424	1.55334	"	7.0	1.167		–

Except Rubens' values, — means from various authorities.

TABLE 176.

INDEX OF REFRACTION.

Various Monorefringent or Optically Isotropic Solids.

Substance.	Line of Spectrum.	Index of Refraction.	Authority.
Agate (light color)	red	1.5374	De Senarmont.
Ammonium chloride	D	1.6422	Grailich.
Arsenite	D	1.755	DesCloiseaux.
Barium nitrate	D	1.5716	Fock.
Bell metal	D	1.0052	Beer.
Blende	Li	2.34165	Ramsay.
	Na	2.36923	
	Tl	2.40069	
Boric acid	C	1.46245	Bedson and Carleton Williams.
	D	1.46303	
	F	1.47024	
Borax (vitrified)	C	1.51222	
	D	1.51484	
	F	1.52068	
Camphor	D	1.532 1.5462	Kohlrausch. Mulheims.
Diamond (colorless)	red	2.414	DesCloiseaux.
	green	2.428	
Diamond (brown)	B	2.46062	Schrauf.
	D	2.46986	
	E	2.47902	
Ebonite	D	1.6	Ayrton & Perry.
Fuchsin	A	2.03	Means.
	B	2.19	
	C	2.33	
	G	1.97	
	H	1.32	
Garnet (different varieties)	D	1.74 to 1.90	Various.
Gum arabic	red	1.480	Jamin.
“ “	“	1.514	Wollaston.
Hanyne	D	1.4961	Tschichatscheff.
Helvine	D	1.739	Levy & Lecroix.
Obsidian	D	1.482 to 1.496	Various.
Opal	D	1.406 1.450	“
Pitch	red	1.531	Wollaston.
Potassium bromide	D	1.5593	Topsöe and Christiansen.
“ chlorstannate	“	1.6574	
“ iodide	“	1.6666	
Phosphorus	“	2.1442	Gladstone & Dale.
Resins: Aloes	red	1.619	Jamin.
Canada balsam	“	1.528	Wollaston.
Colophony	“	1.548	Jamin.
Copal	“	1.528	“
Mastic	“	1.535	Wollaston.
Peru balsam	D	1.593	Baden Powell.
Selenium, vitreous	A	2.612	Wood.
	B	2.680	
	C	2.729	
	D	2.93	
Silver bromide	D	2.253	Wernicke.
chloride	“	2.061	
iodide	“	2.182	
Sodalite blue	“	1.4827	Feusner.
clear like water	“	1.4833	
Sodium chlorate	“	1.5150	Dussaud.
Spinel	“	1.7155	DesCloiseaux.
Strontium nitrate	“	1.5667	Fock.

INDEX OF REFRACTION.

TABLE 177. — Uniaxial Crystals.

Substance.	Line of spectrum.	Index of refraction.		Authority.
		Ordinary ray.	Extraordinary ray.	
Alunite (alum stone)	D	1.573	1.592	Levy & Lacroix.
Ammonium arseniate	red	1.577	4.524	De Senarmont.
Anatase	D	2.5354	2.4959	Schrauf.
Apatite	D	1.6390	1.6345	"
Benzil	D	1.6588	1.6784	DesCloiseaux.
Beryl	D	1.589 to 1.570	1.582 to 1.566	Various.
Brucite	D	1.560	1.581	Kohlrausch.
Calomel	red	1.96	2.60	De Senarmont.
Cinnabar	red	2.854	3.199	DesCloiseaux.
Corundum (ruby, sapphire, etc.)	red	1.767 to 1.769	1.759 1.762	"
Dioptase	green	1.667	1.723	"
Emerald (pure)	green	1.584	1.578	"
Ice at — 8° C.	D	1.309	1.313	Meyer.
Idocrase	D	1.719 to 1.722	1.717 to 1.720	DesCloiseaux.
Ivory	D	1.539	1.541	Kohlrausch.
Magnesite	D	1.717	1.515	Mallard.
Potassium arseniate	red	1.564	1.515	DesCloiseaux.
" "	red	1.493	1.501	De Sernamont.
Silver (red ore)	red	3.084	2.881	Fizeau.
Sodium arseniate	D	1.459	1.467	Baker.
" nitrate	D	1.587	1.336	Schrauf.
" phosphate	D	1.446	2.452	Dufet.
Strychnine sulphate	D	1.614	1.519	Martin.
Tin stone	D	1.997	2.093	Grubenman.
Tourmaline (colorless)	D	1.637	1.619	Heusser.
" (different colors)	D	1.633 to 1.650	1.616 to 1.625	Jeroféjew.
Zircon (hyacinth)	red	1.92	1.97	De Senarmont.
" "	D	1.924	1.968	Sanger.

TABLE 178. — Biaxial Crystals.

Substance.	Line of spectrum.	Index of refraction.			Authority.
		Minimum.	Intermediate.	Maximum.	
Anglesite	D	1.8771	1.8823	1.8936	Arzruni.
Anhydrite	D	1.5693	1.5752	1.6130	Mülheims.
Antipyrin	D	1.5101	1.6812	1.6858	Glazebrook.
Aragonite	D	1.5301	1.6816	1.6859	Rudberg.
Axinite	red	1.6720	1.6779	1.6810	DesCloiseaux.
Barite	D	1.636	1.637	1.648	Various.
Borax	D	1.4467	1.4694	1.4724	Dufet.
Copper sulphate	D	1.5140	1.5368	1.5433	Kohlrausch.
Gypsum	D	1.5208	1.5228	1.5298	Mülheims.
Mica (muscovite)	D	1.5601	1.5936	1.5977	Pulfrich.
Olivine	D	1.661	1.678	1.697	DesCloiseaux.
Orthoclase	D	1.5190	1.5237	1.5260	"
Potassium bichromate	D	1.7202	1.7380	1.8197	Dufet.
" nitrate	D	1 3346	1.5056	1.5064	Schrauf.
" sulphate	D	1·4932	1.4946	1.4980	Topsöe & Christiansen.
Sugar (cane)	D	1.5397	1.5667	1.5716	Calderon.
Sulphur (rhombic)	D	1.9505	2.0383	2.2405	Schrauf.
Topaz (Brazilian)	D	1.6294	1.6308	1.6375	Mülheims.
Topaz (different kinds)	D	1.630 to 1.613	1.631 to 1.616	1.637 to 1.623	Various.
Zinc sulphate	D	1.4568	1.4801	1.4836	Topsöe & Christiansen.

TABLE 179.

INDEX OF REFRACTION.

Indices of Refraction relative to Air for Solutions of Salts and Acids.

Substance.	Density.	Temp. C.	Indices of refraction for spectrum lines. C	D	F	H_γ	H	Authority.
(a) Solutions in Water.								
Ammonium chloride	1.067	27°.05	1.37703	1.37936	1.38473	–	1.39336	Willigen.
" "	.025	29.75	.34850	.35050	.35515	–	.36243	"
Calcium chloride .	.398	25.65	.44000	.44279	.44938	–	.46001	"
" "	.215	22.9	.39411	.39652	.40206	–	.41078	"
" "	.143	25.8	.37152	.37369	.37876	–	.38666	"
Hydrochloric acid .	1.166	20.75	1.40817	1.41109	1.41774	–	1.42816	"
Nitric acid	.359	18.75	.39893	.40181	.40857	–	.41961	"
Potash (caustic) . .	.416	11.0	.40052	.40281	.40808	–	.41637	Fraunhofer.
Potassium chloride .	normal solution		.34087	.34278	.34719	1.35049	–	Bender.
" "	double normal		.34982	.35179	.35645	.35994	–	"
" "	triple normal		.35831	.36029	.36512	.36890	–	"
Soda (caustic) . .	1.376	21.6	1.41071	1.41334	1.41936	–	1.42872	Willigen.
Sodium chloride . .	.189	18.07	.37562	.37789	.38322	1.38746	–	Schutt.
" "	.109	18.07	.35751	.35959	.36442	.36823	–	"
" "	.035	18.07	.34000	.34191	.34628	.34969	–	"
Sodium nitrate . .	1.358	22.8	1.38283	1.38535	1.39134	–	1.40121	Willigen.
Sulphuric acid . .	.811	18.3	.43444	.43669	.44168	–	.44883	"
" "	.632	18.3	.42227	.42466	.42967	–	.43694	"
" "	.221	18.3	.36793	.37009	.37468	–	.38158	"
" "	.028	18.3	.33663	.33862	.34285	–	.34938	"
Zinc chloride . . .	1.359	26.6	1.39977	1.40222	1.40797	–	1.41738	"
" " . . .	.209	26.4	.37292	.37515	.38026	–	.38845	"
(b) Solutions in Ethyl Alcohol.								
Ethyl alcohol . . .	0.789	25.5	1.35791	1.35971	1.36395	–	1.37094	Willigen.
" "	.932	27.6	.35372	.35556	.35986	–	.36662	"
Fuchsin (nearly saturated)	–	16.0	.3918	.398	.361	–	.3759	Kundt.
Cyanin (saturated) .	–	16.0	.3831	–	.3705	–	.3821	"

Note. — Cyanin in chloroform also acts anomalously; for example, Sieben gives for a 4.5 per cent. solution $\mu_A = 1.4593$, $\mu_B = 1.4695$, μ_F(green) $= 1.4514$, μ_G (blue) $= 1.4554$. For a 9.9 per cent. solution he gives $\mu_A = 1.4902$, μ_F (green) $= 1.4497$, μ_G (blue) $= 1.4597$.

(c) Solutions of Potassium Permanganate in Water.*

Wave-length in cms. × 10^6.	Spectrum line.	Index for 1 % sol.	Index for 2 % sol.	Index for 3 % sol.	Index for 4 % sol.	Wave-length in cms. × 10^6.	Spectrum line.	Index for 1 % sol.	Index for 2 % sol.	Index for 3 % sol.	Index for 4 % sol.
68.7	B	1.3328	1.3342	–	1.3382	51.6	–	1.3368	1.3385	–	–
65.6	C	.3335	.3348	1.3365	.3391	50.0	–	.3374	.3383	1.3386	1.3404
61.7	–	.3343	.3365	.3381	.3410	48.6	F	.3377	–	–	.3408
59.4	–	.3354	.3373	.3393	.3426	48.0	–	.3381	.3395	.3398	.3413
58.9	D	.3353	.3372	–	.3426	46.4	–	.3397	.3402	.3414	.3423
56.8		.3362	.3387	.3412	.3445	44.7	–	.3407	.3421	.3426	.3439
55.3	–	.3366	.3395	.3417	.3438	43.4	–	.3417	–	–	.3452
52.7	E	.3363	–	–	–	42.3	–	.3431	.3442	.3457	.3468
52.2	–	.3362	.3377	.3388	–	–	–	–	–	–	–

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* According to Christiansen.

TABLE 180.

INDEX OF REFRACTION.

Indices of Refraction of Liquids relative to Air.

Substance.	Temp. C.	Index of refraction for spectrum lines.					Authority.
		C	D	F	H_γ	H	
Acetone	10°	1.3626	1.3646	1.3694	1.3732	–	Korten.
Almond oil	0	.4755	.4782	.4847	–	–	Olds.
Analin *	20	.5993	.5863	.6041	.6204	–	Weegmann.
Aniseed oil	21.4	.5410	.5475	.5647	–	–	Willigen.
“ “	15.1	.5508	.5572	.5743	–	1.6084	Baden Powell.
Benzene †	10	1.4983	1.5029	1.5148	–	1.5355	Gladstone.
“	21.5	.4934	.4979	.5095	–	.5304	“
Bitter almond oil	20	.5391	–	.5623	.5775	–	Landolt.
Bromnaphtalin	20	.6495	.6582	.6819	.7041	.7289	Walter.
Carbon disulphide ‡	0	1.6336	1.6433	1.6688	1.6920	1.7175	Ketteler.
“ “	20	.6182	.6276	.6523	.6748	.6994	“
“ “	10	.6250	.6344	.6592	–	.7078	Gladstone. '
“ “	19	.6189	.6284	.6352	–	.7010	Dufet.
Cassia oil	10	.6007	.6104	.6389	–	.7039	Baden Powell.
“ “	22.5	.5930	.6026	.6314	–	.6985	“ “
Chinolin	20	1.6094	1.6171	1.6361	1.6497	–	Gladstone.
Chloroform	10	.4466	.4490	.4555	–	.4661	Gladstone & Dale.
“	30	–	.4397	–	–	.4561	“ “
“	20	.4437	.4462	.4525	–	–	Lorenz.
Cinnamon oil	23.5	.6077	.6188	.6508	–	–	Willigen.
Ether	15	1.3554	1.3566	1.3606	–	1.3683	Gladstone & Dale.
“	15	.3573	.3594	.3641	–	.3713	Kundt.
Ethyl alcohol	0	.3677	.3695	.3739	.3773	–	Korten.
“ “	10	.3636	.3654	.3698	.3732	–	“
“ “	20	.3596	.3614	.3657	.3690	–	“
“ “	15	.3621	.3638	.3683	–	.3751	Gladstone & Dale.
Glycerine	20	1.4706	–	1.4784	1.4828	–	Landolt.
Methyl alcohol	15	.3308	1.3326	.3362	–	.3421	Baden Powell.
Olive oil	0	.4738	.4763	.4825	–	–	Olds.
Rock oil	0	.4345	.4573	.4644	–	–	“
Turpentine oil	10.6	1.4715	1.4744	1.4817	–	1.4939	Fraunhofer.
“ “	20.7	.4692	.4721	.4793	–	.4913	Willigen.
Toluene	20	.4911	.4955	.5070	.5170	–	Bruhl.
Water §	20	.3312	.3330	.3372	.3404	.3435	Means.

* Weegmann gives $\mu_D = 1.59668 - .000518\,t$. Knops gives $\mu_F = 1.61500 - .00056\,t$.

† Weegmann gives $\mu_D = 1.51474 - .000665\,t$. Knops gives $\mu_D = 1.51399 - .000644\,t$.

‡ Wüllner gives $\mu_C = 1.63407 - .00078\,t$; $\mu_F = 1.66908 - .00082\,t$; $\mu_h = 1.69215 - .00085\,t$.

§ Dufet gives $\mu_D = 1.33397 - 10^{-7}(125\,t + 20.6\,t^2 - .000435\,t^3 - .00115\,t^4)$ between 0° and 50°; and nearly the same variation with temperature was found by Ruhlmann, namely, $\mu_D = 1.33373 - 10^{-7}(20.14\,t^2 + .000494\,t^4)$.

TABLE 181.

INDEX OF REFRACTION.

Indices of Refraction of Gases and Vapors.

A formula was given by Biot and Arago expressing the dependence of the index of refraction of a gas on pressure and temperature. More recent experiments confirm their conclusions. The formula is $n_t - 1 = \frac{n_0 - 1}{1 + \alpha t} \cdot \frac{p}{760}$, where n_t is the index of refraction for temperature t, n_0 for temperature zero, α the coefficient of expansion of the gas with temperature, and p the pressure of the gas in millimetres of mercury. Taking the mean value, for air and white light, of $n_0 - 1$ as 0.0002936 and α as 0.00367 the formula becomes

$$n_t - 1 = \frac{.0002936}{1 + .00367t} \cdot \frac{P}{1.0136 \times 10^6} = \frac{.0002895}{1 + .00367} \frac{P}{10^6},$$

where P is the pressure in dynes per square centimetre, and t the temperature in degrees Centigrade.

(a) The following table gives some of the values obtained for the different Fraunhofer lines for air.

Spectrum line.	Index of refraction according to — Ketteler.	Lorenz.	Kayser & Runge.	Spectrum line.	Index of refraction according to Kayser & Runge.
A	1.0002929	1.0002893	1.0002905	M	1.0002993
B	2935	2899	2911	N	3003
C	2938	2902	2914	O	3015
D	2947	2911	2922		
E	2958	2922	2933	P	1.0003023
				Q	3031
F	1.0002968	1.0002931	1.0002943	R	3043
G	2987	2949	2962		
H	3003	2963	2978	S	1.0003053
K	–	–	2980	T	3064
L	–	–	2987	U	3075

(b) The following are compiled mostly from a table published by Brühl (Zeits. für Phys. Chem. vol. 7, pp. 25–27). The numbers are from the results of experiments by Biot and Arago, Dulong, Jamin, Ketteler, Lorenz, Mascart, Chappius, Rayleigh, and Rivière and Prytz. When the number given rests on the authority of one observer the name of that observer is given. The values are for 0° Centigrade and 760 mm. pressure.

Substance.	Kind of light.	Indices of refraction and authority.	Substance.	Kind of light.	Indices of refraction and authority.
Acetone	D	1.001079–1.001100	Hydrogen	white	1.000138–1.000143
Ammonia	white	1.000381–1.000385	"	D	1.000132 Burton.
"	D	1.000373–1.000379	Hydrogen sulphide	D	1.000644 Dulong.
Argon	D	1.000281 Rayleigh.		D	1.000623 Mascart.
Benzene	D	1.001700–1.001823	Methane	white	1.000443 Dulong.
Bromine	D	1.001132 Mascart.	"	D	1.000444 Mascart.
Carbon dioxide	white	1.000449–1.000450	Methyl alcohol	D	1.000549–1.000623
" "	D	1.000448–1.000454	Methyl ether	D	1.000891 Mascart.
Carbon disulphide	white	1.001500 Dulong.	Nitric oxide	white	1.000303 Dulong.
	D	1.001478–1.001485	" "	D	1.000297 Mascart.
Carbon monoxide	white	1.000340 Dulong.	Nitrogen	white	1.000295–1.000300
	white	1.000335 Mascart.	"	D	1.000296–1.000298
Chlorine	white	1.000772 Dulong.	Nitrous oxide	white	1.000503–1.000507
"	D	1.000773 Mascart.	" "	D	1.000516 Mascart.
Chloroform	D	1.001436–1.001464	Oxygen	white	1.000272–1.000280
Cyanogen	white	1.000834 Dulong.	"	D	1.000271–1.000272
"	D	1.000784–1.000825	Pentane	D	1.001711 Mascart.
Ethyl alcohol	D	1.000871–1.000885	Sulphur dioxide	white	1.000665 Dulong.
Ethyl ether	D	1.001521–1.001544	" "	D	1.000686 Ketteler.
Helium	D	1.000036 Ramsay.	Water	white	1.000261 Jamin.
Hydrochloric acid	white	1.000449 Mascart.	"	D	1.000249–1.000259
	D	1.000447 "			

According to Fresnel the amount of light reflected by the surface of a transparent medium $=\frac{1}{2}(A+B)=\frac{1}{2}\left\{\frac{\sin^2(i-r)}{\sin^2(i+r)}+\frac{\tan^2(i-r)}{\tan^2(i+r)}\right\}$; A is the amount polarized in the plane of incidence; B is that polarized perpendicular to this; i and r are the angles of incidence and refraction.

TABLE 182.—Light reflected when $i = 0°$ or Incident Light is Normal to Surface.

n.	$\frac{1}{2}(A+B)$.	n.	$\frac{1}{2}(A+B)$.	n.	$\frac{1}{2}(A+B)$.	n.	$\frac{1}{2}(A+B)$.
1.00	0.00	1.4	2.78	2.0	11.11	5.	44.44
1.02	0.01	1.5	4.00	2.25	14.06	5.83	50.00
1.05	0.06	1.6	5.33	2.5	18.37	10.	66.67
1.1	0.23	1.7	6.72	2.75	22.89	100.	96.08
1.2	0.83	1.8	8.16	3.	25.00	∞	100.00
1.3	1.70	1.9	9.63	4.	36.00		

TABLE 183.—Light reflected when n is near Unity or equals $1 + dn$.

i.	A.	B.	$\frac{1}{2}(A+B)$.	$\frac{A-B}{A+B}$.*
0°	1.000	1.000	1.000	0.0
5	1.015	.985	1.000	1.5
10	1.063	.939	1.001	6.2
15	1.149	.862	1.005	14.3
20	1.282	.752	1.017	26.0
25	1.482	.612	1.047	41.5
30	1.778	.444	1.111	60.0
35	2.221	.260	1.240	79.1
40	2.904	.088	1.496	94.5
45	4.000	.000	2.000	100.0
50	5.857	.176	3.016	94.5
55	9.239	1.081	5.160	79.1
60	16.000	4.000	10.000	60.0
65	31.346	12.952	22.149	41.5
70	73.079	42.884	57.981	26.0
75	222.85	167.16	195.00	14.3
80	1099.85	971.21	1035.53	6.2
85	17330.64	16808.08	17069.36	1.5
90	∞	∞	∞	0.0

TABLE 184.—Light reflected when $n = 1.55$.

i.	r.	A.	B.	dA.†	dB.†	$\frac{1}{2}(A+B)$.	$\frac{A-B}{A+B}$.*
° ′	° ′						
0	0 0.0	4.65	4.65	0.130	0.130	4.65	0.0
5	3 13.4	4.70	4.61	.131	.129	4.65	1.0
10	6 25.9	4.84	4.47	.135	.126	4.66	4.0
15	9 36.7	5.09	4.24	.141	.121	4.66	9.1
20	12 44.8	5.45	3.92	.150	.114	4.68	16.4
25	15 49.3	5.95	3.50	.161	.105	4.73	25.9
30	18 49.1	6.64	3.00	.175	.094	4.82	37.8
35	21 43.1	7.55	2.40	.191	.081	4.98	51.7
40	24 30.0	8.77	1.75	.210	.066	5.26	66.7
45	27 8.5	10.38	1.08	.233	.049	5.73	81.2
50	29 37.1	12.54	0.46	.263	.027	6.50	92.9
55	31 54.2	15.43	0.05	.303	.007	7.74	99.3
60	33 58.1	19.35	0.12	.342	—.013	9.73	98.8
65	35 47.0	24.69	1.13	.375	—.032	12.91	91.2
70	37 19.1	31.99	4.00	.400	—.050	18.00	77.7
75	38 32.9	42.00	10.38	.410	—.060	26.19	61.8
80	39 26.8	55.74	23.34	.370	—.069	39 54	41.0
82 30	39 45.9	64.41	34.04	.320	—.067	49.22	30.8
85 0	39 59.6	74.52	49.03	.250	—.061	61.77	20.6
86 0	40 3.6	79.02	56.62	.209	—.055	67.82	16.5
87 0	40 6.7	83.80	65.32	.163	—.046	74.56	12.4
88 0	40 8.9	88.88	75.31	.118	—.036	82.10	8.3
89 0	40 10.2	94.28	86.79	.063	—.022	90.54	4.1
90 0	40 10.7	100.00	100.00	.000	—.000	100.00	0.0

Angle of total polarization $= 57° 10'.3$, $A = 16.99$.

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* This column gives the degree of polarization.

† Columns 5 and 6 furnish a means of determining A and B for other values of n. They represent the change in these quantities for a change of n of 0.01.

Taken from E. C. Pickering's "Applications of Fresnel's Formula for the Reflection of Light."

TABLE 185.

REFLECTION OF METALS.

Perpendicular Incidence and Reflection.

The numbers give the per cents of the incident radiation reflected.

Wave-length, μ.	Silver-backed Glass.	Mercury-backed Glass.	Mach's Magnalium. $69Al+31Mg$.	Brandes-Schünemann Alloy. $32Cu+34Sn+29Ni+5Fe$.	Ross' Speculum Metal. $68.2Cu+31.8Sn$.	Nickel. *Electrolytically Deposited.*	Copper. *Electrolytically Deposited.*	Steel. *Untempered.*	Copper. *Commercially Pure.*	Platinum. *Electrolytically Deposited.*	Gold. *Electrolytically Deposited.*	Brass. *(Trowbridge).*	Silver. *Chemically Deposited.*
.251	-	-	67.0	35.8	29.9	37.8	-	32.9	25.9	33.8	38.8	-	34.1
.288	-	-	70.6	37.1	37.7	42.7	-	35.0	24.3	38.8	34.0	-	21.2
.305	-	-	72.2	37.2	41.7	44.2	-	37.2	25.3	39.8	31.8	-	9.1
.316	-	-	-	-	-	-	-	-	-	-	-	-	4.2
.326	-	-	75.5	39.3	-	45.2	-	40.3	24.9	41.4	28.6	-	14.6
.338	-	-	-	-	-	46.5	-	-	-	-	-	-	55.5
.357	-	-	81.2	43.3	51.0	48.8	-	45.0	27.3	43.4	27.9	-	74.5
.385	-	-	83.9	44.3	53.1	49.6	-	47.8	28.6	45.4	27.1	-	81.4
.420	-	-	83.3	47.2	56.4	56.6	-	51.9	32.7	51.8	29.3	-	86.6
.450	85.7	72.8	83.4	49.2	60.0	59.4	48.8	54.4	37.0	54.7	33.1	-	90.5
.500	86.6	70.9	83.3	49.3	63.2	60.8	53.3	54.8	43.7	58.4	47.0	-	91.3
.550	88.2	71.2	82.7	48.3	64.0	62.6	59.5	54.9	47.7	61.1	74.0	-	92.7
.600	88.1	69.9	83.0	47.5	64.3	64.9	83.5	55.4	71.8	64.2	84.4	-	92.6
.650	89.1	71.5	82.7	51.5	65.4	66.6	89.0	56.4	80.0	66.5	88.9	-	94.7
.700	89.6	72.8	83.3	54.9	66.8	68.8	90.7	57.6	83.1	69.0	92.3	-	95.4
.800	-	-	84.3	63.1		69.6	-	58.0	88.6	70.3	94.9	-	96.8
1.0	-	-	84.1	69.8	70.5	72.0	-	63.1	90.1	72.9	-	-	97.0
1.5	-	-	85.1	79.1	75.0	78.6	-	70.8	93.8	77.7	97.3	-	98.2
2.0	-	-	86.7	82.3	80.4	83.5	-	76.7	95.5	80.6	96.8	91.0	97.8
3.0	-	-	87.4	85.4	86.2	88.7	-	83.0	97.1	88.8	-	93.7	98.1
4.0	-	-	88.7	87.1	88.5	91.1	-	87.8	97.3	91.5	96.9	95.7	98.5
5.0	-	-	89.0	87.3	89.1	94.4	-	89.0	97.9	93.5	97.0	95.9	98.1
7.0	-	-	90.0	88.6	90.1	94.3	-	92.9	98.3	95.5	98.3	97.0	98.5
9.0	-	-	90.6	90.3	92.2	95.6	-	92.9	98.4	95.4	98.0	97.8	98.7
11.0	-	-	90.7	90.2	92.9	95.9	-	94.0	98.4	95.6	98.3	96.6	98.8
14.0	-	-	92.2	90.3	93.6	97.2	-	96.0	97.9	96.4	97.9	-	98.3

Based upon the work of Hagen and Rubens, Ann. der Phys. (1) 352, 1900; (8) 1, 1902; (11) 873, 1903.
Taken partly from Landolt-Börnstein-Meyerhoffer's Physikalisch-chemische Tabellen.

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TRANSMISSIBILITY FOR RADIATION OF JENA GLASSES.

TABLE 188.

Coefficients, *a*, in the formula $I_t = I_0 a^t$, where I_0 is the Intensity before, and I_t after, transmission through the thickness *t*, expressed in centimetres. Deduced from observations by Müller, Vogel, and Rubens as quoted in Hovestadt's Jena Glass (English translation).

Type of Glass.	Coefficient of transmission, *a*.									
λ =	.375 μ	390 μ	.400 μ	.434 μ	.436 μ	.455 μ	.477 μ	.503 μ	.580 μ	.677 μ
O 340, Ord. light flint	.388	.456	.614	.569	.680	.834	.880	.880	.878	.939
O 102, H'vy silicate flint	–	.025	.463	.502	.566	.663	.700	.782	.828	.794
O 93, Ord. " "	–	–	–	–	.714	.807	.899	.871	.903	.943
O 203, " " crown	.583	.583	.695	.667	.806	.822	.860	.872	.872	.903
O 598, (Crown)	–	–	–	–	.797	.770	.771	.776	.818	.860

λ =	0.7 μ	0.95 μ	1.1 μ	1.4 μ	1.7 μ	2.0 μ	2.3 μ	2.5 μ	2.7 μ	2.9 μ	3.1 μ
S 204, Borate crown	1.0	.90	.55	.37	.21	.12	.025	.02	.04	.03	
S 179, Med. phosp. cr.	–	.82	.61	.37	.17	.018	.08	.25	.05		
O 1143, Dense, bor. sil. cr.	–	–	.74	–	.61	.50	.33	.18	.034	.06	.021
O 1092, Crown	.91	.67	.61	.90	.91	.41	.14	.033	.006	.07	.043
O 1151, "	.82	–	.91	.90	.82	.55	.33	.10	.055	.04	.010
O 451, Light flint	1.0	–	.91	–	.82	.61	.45	.17	.083	.002	.019
O 469, Heavy "	1.0	–	.82	–	.91	.82	.82	.74	.33	.017	.010
O 500, " "	1.0	–	1.0	–	1.0	–	1.0	.90	.45	.050	.019
S 163, " "	1.0	–	.82	–	.91	–	.91	–	.55	.083	.062

TABLE 187.

Note: With the following data, *t* must be expressed in millimetres; i. e. the figures as given give the transmissions for thickness of 1 mm.

No. and Type of Glass.	Wave-length in μ.												
	Visible Spectrum.							Ultra-violet Spectrum.					
	.644 μ	.578 μ	.546 μ	.509 μ	.480 μ	.436 μ	.405 μ	.384 μ	.361 μ	.340 μ	.332 μ	.309 μ	.280 μ
F 3815 Dark neutral	.35	.35	.37	.35	.34	.30	.15	.06					
F 4512 Red filter	.94	.05											
F 2745 Copper ruby	.72	.39	.47	.47	.45	.43	.43						
F 4313 Dark yellow	.98	.97	.93	.83	.09								
F 4351 Yellow	.98	.97	.96	.93	.44	.15							
F 4937 Bright yellow	1.0	1.0	1.0	.99	.74	.40	.31	.28	.22	.18	.14	.06	
F 4930 Green filter	.17	.50	.64	.62	.44								
F 3873 Blue filter	–	–	–	.18	.50	.73	.69	.59	.36	.10			
F 3654 Cobalt glass, transparent for outer red	–	–	–	.15	.44	.85	1.0	1.0	1.0	1.0	1.0	.58	
F 3653 Blue, ultraviolet	–	–	–	–	.11	.65	1.0	1.0	1.0	1.0	1.0	.81	.18
F 3728 Didymium, str'g bands	.99	.72	.99	.96	.95	.96	.99	.99	.89	.89	.77	.54	

This and the following table are taken from Jenaer Glas für die Optik, Liste 751, 1909.

TABLE 188. — Transmissibility of Jena Ultra-violet Glasses.

No. and Type of Glass.	Thickness.	0.397 μ	0.383 μ	0.361 μ	0.346 μ	0.325 μ	0.309 μ	0.280 μ
UV 3199 Ultra-violet	1 mm.	1.00	1.00	1.00	1.00	1.00	0.95	0.56
" "	2 mm.	0.99	0.99	0.99	0.97	0.90	0.57	
" "	1 dm.	0.95	0.95	0.89	0.70	0.36		
UV 3248 "	1 mm.	1.00	1.00	1.00	1.00	0.98	0.91	0.35
" "	2 mm.	0.98	0.98	0.98	0.92	0.78	0.38	
" "	1 dm.	0.96	0.87	0.79	0.45	0.08		

TABLE 189.

TRANSMISSIBILITY FOR RADIATION.

Transmissibility of the Various Substances of Tables 166 to 175.

Alum: Ordinary alum (crystal) absorbs the infra-red.
Metallic reflection at 9.05μ and 30 to 40μ.

Rock-salt: Rubens and Trowbridge (Wied. Ann. 65, 1898) give the following transparencies for a 1 cm. thick plate in %:

λ	9	10	12	13	14	15	16	17	18	19	20.7	23.7μ
%	99.5	99.5	99.3	97.6	93.1	84.6	66.1	51.6	27.5	9.6	0.6	0.

Pflüger (Phys. Zt. 5. 1904) gives the following for the ultra-violet, same thickness: 280μμ, 95.5%; 231, 86%; 210, 77%; 186, 70%.
Metallic reflection at 0.110μ, 0.156, 51.2, and 87μ.

Sylvine: Transparency of a 1 cm. thick plate (Trowbridge, Wied. Ann. 60, 1897).

λ	9	10	11	12	13	14	15	16	17	18	19	20.7	23.7μ
%	100.	98.8	99.0	99.5	99.5	97.5	95.4	93.6	92.	86.	76.	58.	15.

Metallic reflection at 0.114μ, 0.161, 61.1, 100.

Fluorite: Very transparent for the ultra-violet nearly to 0.1μ.
Rubens and Trowbridge give the following for a 1 cm. plate (Wied. Ann. 60, 1897):

λ	8μ	9	10	11	12μ
%	84.4	54.3	16.4	1.0	0

Metallic reflection at 24μ, 31.6, 40μ.

Iceland Spar: Merritt (Wied. Ann. 55, 1895) gives the following values of *k* in the formula $i = i_0 e^{-kd}$ (d in cm.):
For the ordinary ray:

λ	1.02	1.45	1.72	2.07	2.11	2.30	2.44	2.53	2.60	2.65	2.74μ
k	0.0	0.0	0.03	0.13	0.74	1.92	3.00	1.92	1.21	1.74	2.36

λ	2.83	2.90	2.95	3.04	3.30	3.47	3.62	3.80	3.98	4.35	4.52	4.83μ
k	1.32	0.70	1.80	4.71	22.7	19.4	9.6	18.6	∞	6.6	14.3	6.1

For the extraordinary ray:

λ	2.49	2.87	3.00	3.28	3.38	3.59	3.76	3.90	4.02	4.41	4.67μ
k	0.14	0.08	0.43	1.32	0.89	1.79	2.04	1.17	0.89	1.07	2.40

λ	4.91	5.04	5.34	5.50μ
k	1.25	2.13	4.41	12.8

Quartz: Very transparent to the ultra-violet; Pflüger gets the following transmission values for a plate 1 cm. thick: at 0.222μ, 94.2%; 0.214, 92; 0.203, 83.6; 0.186, 67.2%.
Merritt (Wied. Ann. 55, 1895) gives the following values for *k* (see formula under Iceland Spar):
For the ordinary ray:

λ	2.72	2.83	2.95	3.07	3.17	3.38	3.67	3.82	3.96	4.12	4.50μ
k	0.20	0.47	0.57	0.31	0.20	0.15	1.26	1.61	2.04	3.41	7.30

For the extraordinary ray:

λ	2.74	2.89	3.00	3.08	3.26	3.43	3.52	3.59	3.64	3.74	3.91	4.19	4.36μ
k	0.0	0.11	0.33	0.26	0.11	0.51	0.76	1.88	1.83	1.62	2.22	3.35	8.0

For λ > 7 μ, becomes opaque, metallic reflection at 8.50μ, 9.02, 20.75–24.4μ, then transparent again.

The above are taken from Kayser's "Handbuch der Spectroscopie," vol. iii.

TRANSMISSIBILITY FOR RADIATION.

TABLE 190. — Color Screens.

The following light-filters are quoted from Landolt's "Das optische Drehungsvermögen, etc." 1898. Although only the potassium salt does not keep well it is perhaps safer to use freshly prepared solutions.

Color.	Thickness. mm.	Water solutions of	Grammes of substance in 100 c.cm.	Optical centre of band. μ	Transmission.
Red	20	Crystal-violet, 5BO	0.005	0.6659	begins about 0.718μ. ends sharp at 0.639μ.
"	20	Potassium monochromate	10.		
Yellow	20	Nickel-sulphate, $NiSO_4$.7aq.	30.	0.5919	0.614–0.574μ,
"	15	Potassium monochromate	10.		
"	15	Potassium permanganate	0.025		
Green	20	Copper chloride, $CuCl_2$.2aq.	60.	0.5330	0.540–0.505μ
"	20	Potassium monochromate	10.		
Bright blue	20	Double-green, SF	0.02	0.4885	0.526–0.494 and 0.494–0.458μ
	20	Copper-sulphate, $CuSO_4$.5aq.	15.		
Dark blue	20	Crystal-violet, 5BO	0.005	0.4482	0.478–0.410μ
	20	Copper sulphate, $CuSO_4$.5aq.	15.		

TABLE 191. — Color Screens.

The following list is condensed from Wood's Physical Optics, 2nd edition:

Methyl violet, 4R· (Berlin Anilin Fabrik) very dilute, and nitroso-dimethyl-aniline transmits 0.365μ. Methyl violet + chinin-sulphate (separate solutions), the violet solution made strong enough to blot out 0.4359μ, transmits 0.4047 and 0.4048, also faintly 0.3984.

Cobalt glass + aesculin solution transmits 0.4359μ.

Guinea green B extra (Berlin) + chinin sulphate transmits 0.4916μ.

Neptune green (Bayer, Elberfeld) + chrysoidine. Dilute the latter enough to just transmit 0.5790 and 0.5461; then add the Neptune green until the yellow lines disappear.

Chrysoidine + eosine transmits 0.5790μ. The former should be dilute and the eosine added until the green line disappears.

Silver chemically deposited on a quartz plate is practically opaque except to the ultra-violet region 0.3160–0.3260 where 90% of the energy passes through. The film should be of such thickness that a window backed by a brilliantly lighted sky is barely visible.

In the following those marked with a * are transparent to a more or less degree to the ultra-violet:

* Cobalt chloride: solution in water, — absorbs 0.50–.53μ; addition of $CaCl_2$ widens the band to 0.47–.50. It is exceedingly transparent to the ultra-violet down to 0.20. If dissolved in methyl alcohol + water, absorbs 0.50–.53 and everything below 0.35. In methyl alcohol alone 0.485–0.555 and below 0.40μ.

Copper chloride: in ethyl alcohol absorbs above 0.585 and below 0.535; in alcohol + 50% water, above 0.595 and below 0.37μ.

Neodymium salts are useful combined with other media, sharpening the edges of the absorption bands. In solution with bichromate of potash, transmits 0.535–.565 and above 0.60μ, the bands very sharp (a useful screen for photographing with a visually corrected objective).

Praesodymium salts: three strong bands at 0.482, .468, .444. In strong solutions they fuse into a sharp band at 0.435–.485μ. Absorption below 0.34.

Picric acid absorbs 0.36–.42μ, depending on the concentration.

Potassium chromate absorbs 0.40–.35, 0.30–.24, transmits 0.23μ.

* Potassium permanganate: absorbs 0.555–.50, transmits all the ultra-violet.

Chromium chloride: absorbs above 0.57, between 0.50 and .39, and below 0.33μ. These limits vary with the concentration.

Aesculin: absorbs below 0.363μ, very useful for removing the ultra-violet.

* Nitroso-dimethyl-aniline: very dilute aqueous solution absorbs 0.49–.37 and transmits all the ultra-violet.

Very dense cobalt glass + dense ruby glass or a strong potassium bichromate solution cuts off everything below 0.70 and transmits freely the red.

Iodine: saturated solution in CS_2 is opaque to the visible and transparent to the infra-red.

TABLE 192.

TRANSMISSIBILITY FOR RADIATION.

Color Screens. Jena Glasses.

	Kind of Glass.	Maker's No.	Color.	Region Transmitted.	Thickness. mm.
1	Copper-ruby . .	2728	Deep red	Only red to 0.6μ	1.7
1a	Gold-ruby . . .	459^{III}	Red	Red, yellow; in thin layers also blue and violet.	
2	Uranium . . .	454^{III}	Bright yellow . . .	Red, yellow, green to E_b; in thin layer also blue	16.
2a	"	455^{III}	Bright yellow, fluoresces.		
3	Nickel	440^{III}	Bright yellow-brown	Red, yellow, green (weakened), blue (very weakened)	11.
4	Chromium . .	414^{III}	Yellow-green . . .	Yellowish-green	10.
4a	"	433^{III}	Greenish-yellow . .	Red, green; from 0.65–.50μ . . .	5.
4b	Green copper . . .	431^{III}	Green.	Green, yellow, some red and blue .	2–3
5	Chromium . . .	432^{III}	Yellow-green . . .	Yellowish-green, some red . . .	2.5
6	Copper chromium	436^{III}	Grass-green . . .	Green	5.
7	Green-filter . .	437^{III}	Dark green	Green (in thin sheets some blue) .	5.
8	" " . . .	438^{III}	" "	Green	
10	Copper	2742	Blue, as $CuSO_4$ . .	Green, blue, violet	5–12
11	Blue-violet . .	447^{III}	Blue, as cobalt glass	Blue, violet	5.
"	" " . . .	"	" " " " .	Blue, violet, blue-green (weakened), *no red*	2–5
12	Cobalt	424^{III}	Blue	Blue, violet, extreme red	4–5
13	Nickel	450^{III}	Dark violet	Violet (G–H), extreme red . . .	6.
14	Violet	452^{III}	" "	Violet (G–H), some weakened . .	7.
15	Gray	444^{III}	Gray, no recognizable color	All parts of the spectrum weakened	0.1–8
16	"	445^{III}			0.1–3

See "Über Farbgläser für wissenschaftliche und technische Zwecke," by Zsigmondy, Z. für Instrumentenkunde, 21, 1901 (from which the above table is taken), and "Über Jenenser Lichtfilter," by Grebe, same volume.

(The following notes are quoted from Everett's translation of the above in the English edition of Hovestadt's "Jena Glass.")

Division of the spectrum into complementary colors:

1st by 2728 (deep red) and 2742 (blue, like copper sulphate).
2nd by 454^{III} (bright yellow) and 447^{III} (blue, like cobalt glass).
3rd by 433^{III} (greenish-yellow) and 424^{III} (blue).

Thicknesses necessary in above: 2728, 1.6–1.7 mm.; 2742, 5; 454^{III}, 16; 447^{III}, 1.5–2.0; 433^{III}, 2.5–3.5; 424^{III}, 3 mm.

Three-fold division into red, green and blue (with violet):

2728, 1.7 mm.; 414^{III}, 10 mm.; 447^{III}, 1.5 mm., or by
2728, 1.7 mm.; 436^{III}, 2.6 mm.; 447^{III}, 1.8 mm.

Grebe found the three following glasses specially suited for the additive methods of three-color projection:

2745, red; 438^{III}, green; 447^{III}, blue violet;

corresponding closely to Young's three elementary color sensations.

Most of the Jena glasses can be supplied to order, but the absorption bands vary somewhat in different meltings.

See also "Atlas of Absorption Spectra," Uhler and Wood, Carnegie Institution Publications, 1907.

TABLE 193.—Tartaric Acid; Camphor; Santonin; Santonic Acid; Cane Sugar.

A few examples are here given showing the effect of wave-length on the rotation of the plane of polarization. The rotations are for a thickness of one decimetre of the solution. The examples are quoted from Landolt & Börnstein's "Phys. Chem. Tab." The following symbols are used: —

p = number grammes of the active substance in 100 grammes of the solution.
c = " " solvent " " " "
q = " " active " " cubic centimetre "

Right-handed rotation is marked +, left-handed —.

Line of spectrum.	Wave-length according to Ångström in cms. × 10⁶.	Tartaric acid,* CuH_6O_6, dissolved in water. q = 50 to 95, temp. = 24° C.	Camphor,* $C_{10}H_{16}O$, dissolved in alcohol. q = 50 to 95, temp. = 22.9° C.	Santonin,† $C_{16}H_{18}O_3$, dissolved in chloroform. q = 75 to 96.5, temp. = 20° C.
B	68.67			— 140°.1 + 0.2085 q
C	65.62	+ 2°.748 + 0.09446 q	38°.549 — 0.0852 q	— 149.3 + 0.1555 q
D	58.92	+ 1.950 + 0.13030 q	51.945 — 0.0964 q	— 202.7 + 0.3086 q
E	52.69	+ 0.153 + 0.17514 q	74.331 — 0.1343 q	— 285.6 + 0.5820 q
b_1	51.83	– –	– –	— 302.38 + 0.6557 q
b_2	51.72	— 0.832 + 0.19147 q	79.348 — 0.1451 q	– –
F	48.61	— 3.598 + 0.23977 q	99.601 — 0.1912 q	— 365.55 + 0.8284 q
e	43.83	— 9.657 + 0.31437 q	149.696 — 0.2346 q	— 534.98 + 1.5240 q

		Santonin,† $C_{15}H_{18}O_3$,* dissolved in alcohol. c = 1.782. temp. = 20° C.	Santonin,† $C_{15}H_{18}O_3$,		Santonic acid,† $C_{15}H_{20}O_4$, dissolved in chloroform. c = 27.192. temp. = 20° C.	Cane sugar,‡ $C_{12}H_{22}O_{11}$, dissolved in water. p = 10 to 30.
			dissolved in alcohol. c = 4.046. temp. = 20° C.	dissolved in chloroform c = 3.1–30.5. temp. = 20° C.		
B	68.67	— 110.4°	442°	484°	— 49°	47°.56
C	65.62	— 118.8	504	549	— 57	52.70
D	58.92	— 161.0	693	754	— 74	60.41
E	52.69	— 222.6	991	1088	— 105	84.56
b_1	51.83	— 237.1	1053	1148	— 112	–
b_2	51.72	–	–	–	–	87.88
F	48.61	— 261.7	1323	1444	— 137	101.18
e	43.83	— 380.0	2011	2201	— 197	–
G	43.07	–	–	–	–	131.96
g	42.26	–	2381	2610	— 230	–

* Arndtsen, "Ann. Chim. Phys." (3) 54, 1858.
† Narini, "R. Acc. dei Lincei," (3) 13, 1882.
‡ Stefan, "Sitzb. d. Wien. Akad." 52, 1865.

TABLE 194.—Sodium Chlorate; Quartz.

Sodium chlorate (Guye, C. R. 108, 1889).

Spectrum line.	Wave-length.	Temp. C.	Rotation per mm.
α	71.769	15°.0	2°.068
B	67.889	17.4	2.318
C	65.073	20.6	2.599
D	59.085	18.3	3.104
E	53.233	16.0	3.841
F	48.912	11.9	4.587
G	45.532	10.1	5.331
G	42.834	14.5	6.005
H	40.714	13.3	6.754
L	38.412	14.0	7.654
M	37.352	10.7	8.100
N	35.818	12.9	8.861
P	33.931	12.1	9.801
Q	32.341	11.9	10.787
R	30.645	13.1	11.921
T	29.918	12.8	12.424
Cd_{17}	28.270	12.2	13.426
Cd_{18}	25.038	11.6	14.965

Quartz (Soret & Sarasin, Arch. de Gen. 1882, or C. R. 95, 1882).*

Spectrum line.	Wave-length.	Rotation per mm.	Spectrum line.	Wave-length.	Rotation per mm.
A	76.04	12°.668	Cd_9	36.090	63°.628
a	71.836	14.304	N	35.818	64.459
B	68.671	15.746	Cd_{10}	34.655	69.454
C	65.621	17.318	O	34.406	70.587
D_1	58.951	21.684	Cd_{11}	34.015	72.448
D_2	58.891	21.727	P	33.600	74.571
E	52.691	27.543	Q	32.858	78.579
F	48.607	32.773	Cd_{12}	32.470	80.459
G	43.072	42.604	R	31.798	84.972
h	41.012	47.481	Cd_{17}	27.467	121.052
H	39.681	51.193	Cd_{18}	25.713	143.266
K	39.333	52.155	Cd_{23}	23.125	190.426
L	38.196	55.625	Cd_{24}	22.645	201.824
M	37.262	58.894	Cd_{25}	21.935	220.731
			Cd_{26}	21.431	235.972

* The paper is quoted from a paper by Ketteler in "Wied. Ann." vol. 21, p. 444. The wave-lengths are for the Fraunhofer lines, Ångström's values for the ultra violet sun, and Cornu's values for the cadmium lines.

TABLE 195.

NEWTON'S RINGS.

Newton's Table of Colors.

The following table gives the thickness in millionths of an inch, according to Newton, of a plate of air, water, and glass corresponding to the different colors in successive rings commonly called colors of the first, second, third, etc., orders.

Order.	Color for reflected light.	Color for transmitted light.	Thickness in millionths of an inch for — Air.	Water.	Glass.
I.	Very black	—	0.5	0.4	0.2
	Black	White	1.0	0.75	0.9
	Beginning of black	—	2.0	1.5	1.3
	Blue	Yellowish red	2.4	1.8	1.5
	White	Black	5.2	3.9	3.4
	Yellow	Violet	7.1	5.3	4.6
	Orange	—	8.0	6.0	4.2
	Red	Blue	9.0	6.7	5.8
II.	Violet	White	11.2	3.4	7.2
	Indigo	—	12.8	9.6	8.4
	Blue	Yellow	14.0	10.5	9.0
	Green	Red	15.1	11.3	9.7
	Yellow	Violet	16.3	12.2	10.4
	Orange	—	17.2	13.0	11.3
	Bright red	Blue	18.2	13.7	11.8
	Scarlet	—	19.7	14.7	12.7
III.	Purple	Green	21.0	15.7	13.5
	Indigo	—	21.1	17.6	14.2
	Blue	Yellow	23.2	17.5	15.1
	Green	Red	25.2	18.6	16.2

Order.	Color for reflected light.	Color for transmitted light.	Thickness in millionths of an inch for — Air.	Water.	Glass.
	Yellow	Bluish green	27.1	20.3	17.5
	Red	—	29.0	21.7	18.7
	Bluish red	—	32.0	24.0	20.7
IV.	Bluish green	—	24.0	25.5	22.0
	Green	Red	35.3	26.5	22.7
	Yellowish green	—	36.0	27.0	23.2
	Red	Bluish green	40.3	30.2	26.0
V.	Greenish blue	Red	46.0	34.5	39.7
	Red	—	52.5	39.4	34.0
VI.	Greenish blue	—	58.7	46	38.0
	Red	—	65.0	48.7	42.0
VII.	Greenish blue	—	72.0	53.2	45.8
	Reddish white	—	71.0	57.7	49.4

The above table has been several times revised both as to the colors and the numerical values. Professors Reinold and Rucker, in their investigations on the measurement of the thickness of soap films, found it necessary to make new determinations. They give a shorter series of colors, as they found difficulty in distinguishing slight differences of shade, but divide each color into ten parts and tabulate the variation of thickness in terms of the tenth of a color band. The position in the band at which the thickness is given and the order of color are indicated by numerical subscripts. For example : $R_{1\,5}$ indicates the red of the first order and the fifth tenth from the edge furthest from the red edge of the spectrum. The thicknesses are in millionths of a centimetre.

Order.	Color.	Position.	Thickness.
I.	Red *	$R_{1\,5}$	28.4
II.	Violet	$V_{2\,5}$	30.5
	Blue	$B_{2\,5}$	35.3
	Green	$G_{2\,5}$	40.9
	Yellow *	$Y_{2\,5}$	45.4
	Orange *	$O_{2\,5}$	49.1
	Red	$R_{2\,5}$	52.2
III.	Purple	$P_{3\,5}$	55.9
	Blue	$B_{3\,0}$	57.7
	Blue *	$B_{3\,5}$	60.3
	Green	$G_{3\,5}$	65.6
	Yellow *	$Y_{3\,5}$	71.0

Order.	Color.	Position.	Thickness.
	Red *	$R_{3\,5}$	76.5
	Bluish red *	$BR_{3\,5}$	81.5
IV.	Green	$G_{4\,0}$	84.1
	"	$G_{4\,5}$	89.3
	Yellow green *	$YG_{4\,5}$	96.4
	Red *	$R_{4\,5}$	105.2
V.	Green	$G_{5\,0}$	111.9
	Green *	$G_{5\,5}$	118.8
	Red	$R_{5\,0}$	126.0
	Red *	$R_{5\,5}$	133.5

Order.	Color.	Position.	Thickness.
VI.	Green	$G_{6\,0}$	141.0
	Green *	$G_{6\,5}$	147.9
	Red	$R_{6\,0}$	154.8
	Red *	$R_{6\,5}$	162.7
VII.	Green	$G_{7\,0}$	170.5
	Green *	$G_{7\,5}$	178.7
	Red	$R_{7\,0}$	186.9
	Red *	$R_{7\,5}$	193.6
VIII.	Green	$G_{8\,0}$	200.4
	Red	$R_{8\,0}$	211.5

* The colors marked are the same as the corresponding colors in Newton's table.

TABLE 196.

CONDUCTIVITY FOR HEAT.

The coefficient k is the quantity of heat in small calories which is transmitted per second through a plate one centimetre thick per square centimetre of its surface when the difference of temperature between the two faces of the plate is one degree Centigrade. The coefficient k is found to vary with the absolute temperature of the plate, and is expressed approximately by the equation $k_t = k_0 (1 + at)$. In the table k_0 is the value of k_t for 0° C., t the temperature Centigrade, and a a constant.

Substance.	t	k_t	a	Authority.
Aluminum	0	0.3435	.0005356	1
	100	.3619		
Antimony	0	.0442	—.001041	1
	100	.0396		
Bismuth	0	.0177	—.000735	1
	100	.0164		
Brass (yellow)	0	.2041	.002445	1
	100	.2540		
" (red)	0	.2460	.001492	1
	100	.2827		
Cadmium	0	.2200	—.000705	1
	100	.2045		
Constantin 60Cu+40Ni	18	.5402	–	2
	100	.6405	–	2
Copper	0	.7189	.000051	1
	100	.7226		
German silver	0	.0700	.002670	1
	100	.0887		
Iron	0	.1665	—.000228	1
	100	.1627		
" (wrought)*	0	.2070	–	3
	100	.1567		
Lead	0	.0836	—.000861	1
	100	.0764		
Mercury	0	.0148	–	4
	50	.0189		
Magnesium	0–100	.3760	.000000	1
Manganin 84 Cu+4 Ni+12Mn	18	.5186	–	2
	100	.6310	–	2
Nickel	18	.1420	–	2
Palladium	18	.1683	–	2
Platinum	18	.1664	–	2
	100	.1733	–	2
Steel (hard)	–	.0620		5
" (soft)	–	.1110		5
Silver	0	1.0960	–	4
Tin	0	0.1528	—.000687	1
	100	.1423		
Wood's alloy	-	.0319	–	4
Zinc	18	.2653	–	2

Substance.		t	k_t	Authority.
Carborundum		–	.00050	12
Slate		–	.0036	11
Soil dry		–	.00033	11
" wet		–	.0016	11
Diatomic earth			.00013	12
Fire-brick		–	.00028	12
Granite	from	–	.00510	6
	to	–	.00550	
Lime		–	.00029	12
Magnesia	from	–	.00016	12
	to	–	.00045	
Marbles, limestone, calcite, compact dolomite	from		.00470	6
	to		.00560	
Micaceous flagstone: along cleavage		–	.00632	6
across cleavage		–	.00441	6
Paraffine		–	.00014	8
		0	.00023	9
		100	.00168	9
Pasteboard		–	.00045	8
Plaster of Paris		–	.00070	11
" " " powder		–	.0026	11
Quartz		–	.00036	12
Sand (white dry)			.00093	6
Sandstone and hard grit (dry)	from	–	.00545	6
	to	–	.00565	
Sawdust		–	.00012	8
Serpentine (Cornwall red)		–	.00441	6
Slate: along cleavage	from	–	.00550	6
	to	–	.00650	
across cleavage	from	–	.00315	6
	to	–	.00360	
Snow, compact layers		–	.00051	7
Strawboard		–	.00033	8
Vulcanite			.00087	10
Vulcanized rubber (soft)	from	–	.00034	6
	to		.00054	6
Wax (bees)		–	.00009	8
Wood, fir: parallel to axis		–	.00030	8
perpendicular to axis		–	.00009	8

1 Lorenz.
2 J + D†.
3 J. Forbes.
4 H. F. Weber.
5 Kohlrausch.
6 H. L. & D.‡
7 Hjeltström.
8 G. Forbes.
9 R. Weber.
10 Stefan.
11 Lees-Chorlton.
12 Hutton-Blard.

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* A repetition of Forbes's experiments by Mitchell, under the direction of Tait, shows the conductivity to increase with rise of temperature. (Trans. R. S. E. vol. 33, 1887.)

† Jaeger and Diesselhorst.

‡ Herschel, Lebour, and Dunn (British Association Committee).

CONDUCTIVITY FOR HEAT.

TABLE 197. — Various Substances.

Substance.	t 0	k_t	Authority.
Asbestos paper	–	.00043	5
Blotting paper	–	.00015	5
Carbon	0	.000405	1
Portland cement	–	.00071	5
Cork	0	.000717	1
Cotton wool	0	.000043	1
Cotton pressed	–	.000033	1
Chalk	–	.002000	2
Ebonite	49	.000370	2
Felt	0	.000087	1
Flannel (dry)	0	.00012	1
Glass { from	–	.0011	3
Glass { to	–	.0023	
Horn	–	.000087	1
Haircloth	–	.000042	1
Ice	–	.00223	1
	–	.00568	4
Leather, cow-hide	–	.00042	5
" chamois	–	.00015	5
Linen	–	.00021	5
Silk	–	.000095	5
Caen stone (building limestone)	–	.00433	2
Calc's sandstone (freestone)	–	.00211	2

1 G. Forbes.
2 H., L., & D.*
3 Various.
4 Neumann.
5 Lees-Chorlton.

TABLE 198. — Water and Salt Solutions.

Substance.	Density.	t 0	k_t	Authority.
Water	–	–	.002	1
"	–	0	.00120	2
"	–	9–15	.00136	2
"	–	4	.00129	3
"	–	30	.00157	4
"	–	18	.00124	5
Solutions in water.				
$CuSO_4$	1.160	4.4	.00118	2
KCl	1.026	13	.00116	4
$NaCl$	33⅓%	10–18	.00267	6
H_2SO_4	1.054	20.5	.00126	5
"	1.100	20.5	.00128	5
"	1.180	21	.00130	5
$ZnSO_4$	1.134	4.5	.00118	2
"	1.136	4.5	.00115	2

1 Bottomley.
2 H. F. Weber.
3 Wachsmuth.
4 Graetz.
5 Chree.
6 Winkelmann.

TABLE 199. — Organic Liquids.

Substance.	t 0	k_t ×1000	a	Authority.
Acetic acid	9–15	.472	–	1
Alcohols: amyl	9–15	.328	–	1
ethyl	9–15	.423	–	1
methyl	9–15	.495	–	1
Benzole	5	.333	–	1
Carbon disulphide	9–15	.343	–	1
Chloroform	9–15	.288	–	1
Ether	9–15	.303	–	1
Glycerine	9–15	.637	0.12	2
Oils: olive	–	.395	–	3
castor	–	.425	–	3
petroleum	13	.355	0.011	2
turpentine	13	.325	0.0067	2
Vaseline	–	.44	–	4

1 H. F. Weber.
2 Graetz.
3 Wachsmuth.
4 Lees.

TABLE 200. — Gases.

Substance.	t 0	k_t ×10000	a	Authority.
Air	0	.568	.00190	1
Argon	0	.389	.00260	2
Ammonia	0	.458	.00548	1
Carbon monoxide	0	.499	–	1
" dioxide	0	.307	–	1
Ethylene	0	.395	.00445	1
Helium	0	3.39	.00318	2
Hydrogen	0	3.27	.00175	1
Methane	7–8	.647	–	1
Nitrogen	7–8	.524	–	1
Nitrous oxide	7–8	.350	.00446	1
Oxygen	7–8	.563	–	1

1 Winkelmann.
2 Schwarze.

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* Herschel, Lebour, and Dunn (British Association Committee).

HEAT OF COMBUSTION.

Heat of combustion of some common organic compounds.
Products of combustion, CO_2 or SO_2 and water, which is assumed to be in a state of vapor.

Substance.	Small calories per gramme of substance.	Authority.
Acetylene	11923	Thomsen.
Alcohols: Amyl . . .	8958	Favre and Silbermann.
Ethyl . . .	7183	" " "
Methyl . . .	5307	" " "
Benzene	9977	Stohmann, Kleber, and Langbein.
Coals: Bituminous . . .	7400–8500	Various.
Anthracite . . .	7800	Average of various.
Lignite	6900	" " "
Coke	7000	" " "
Carbon disulphide . . .	3244	Berthelot.
Dynamite, 75%	1290	Roux and Sarran.
Gas: Coal gas	5800–11000	Mahler.
Illuminating . . .	5200–5500	Various.
Methane	13063	Favre and Silbermann.
Naphthalene . . .	9618–9793	Various.
Gunpowder	720–750	"
Oils: Lard	9200–9400	"
Olive	9328–9442	Stohmann.
Petroleum, Am. crude .	11094	Mahler.
" " refined .	11045	"
" Russian . .	10800	"
Woods: Beech with 12.9% H_2O	4168	Gottlieb.
Birch " 11.83 "	4207	"
Oak " 13.3 "	3990	"
Pine " 12.17 "	4422	"

HEAT VALUES AND ANALYSES OF VARIOUS TYPES OF FUEL.

(a) Coals.

Coal.		Moisture.	Volatile Matter.	Fixed Carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories per gramme.	B. T. U.'s per pound.
Lignite	Low grade . .	38.81	25.48	27.29	8.42	.97	7.09	37.45	.50	45.57	3526	6347
	High grade . .	33.38	27.44	29.62	9.56	.94	6.77	41.31	.67	40.75	3994	7189
Sub-bituminous	Low grade .	22.71	34.78	36.60	5.91	.29	6.14	52.54	1.03	34.09	5115	9207
	High grade .	15.54	33.03	46.06	5.37	.58	5.89	60.08	1.05	27.03	5865	10557
Bituminous	Low grade .	11.44	33.93	43.92	10.71	4.94	5.39	60.06	1.02	17.88	6088	10958
	High grade	3.42	34.36	58.83	3.39	.58	5.25	77.98	1.29	11.51	7852	14134
Semi-bituminous	Low grade .	2.7	14.5	75.5	7.3	.99	4.58	80.65	1.82	4.66	7845	14121
	High grade .	3.26	14.57	78.20	3.97	.54	4.76	84.62	1.02	5.09	8166	14699
Semi-anthracite. . . .		2.07	9.81	78.82	9.30	1.74	3.62	80.28	1.47	3.59	7612	13702
Anthracite	Low grade .	2.76	2.48	82.07	12.69	.54	2.23	79.22	.68	4.64	6987	12577
	High grade	3.33	3.27	84.28	9.12	.60	3.08	81.35	.79	5.06	7417	13351

(b) Peats (air dried).

From	Vol. Hydro-Carbon.	Fixed Carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories per gramme.	B.T.U.'s per pound.
Franklin Co., N. Y.	67.10	28.99	3.91	.15	5.93	57.17	1.48	31.36	5726	10307
Sawyer Co., Wis.	56.54	27.92	15.54	.29	4.71	51.00	1.92	26.54	4867	8761

(c) Liquid Fuels.

Fuel.	Specific Gravity at 15° C	Calories per gramme.	British Thermal Units per pound.
Petroleum ether	.684–.694	12210–12220	21978–21996
Gasoline.	.710–.730	11100–11400	19980–20520
Kerosene	.790–.800	11000–11200	19800–20160
Fuel oils, heavy petroleum or refinery residue.	.960–.970	10200–10500	18360–18900
Alcohol, fuel or denatured with 7–9 per cent water and denaturing material . . .	.8196–.8202	6440–6470	11592–11646

Table compiled by U. S. Geological Survey.

Table 203.

CHEMICAL AND PHYSICAL PROPERTIES OF FIVE DIFFERENT CLASSES OF EXPLOSIVES.

Explosive.	Specific gravity.	Number of large calories developed by 1 kilogramme of the explosive.	Pressure developed in own volume after elimination of surface influence.	Unit disruptive charge by ballistic pendulum.	Rate of detonation. Cartridges 1¼ in. diam.	Duration of flame from 100 grammes of explosive.	Length of flame from 100 grammes.	Cartridge 1¼ in. transmitted explosion at a distance of	Products of combustion from 200 grammes; gaseous, solid, and liquid, respectively.	Ignition occurred in 4% fire damp & coal dust mixture with
			Kg. per sq. cm.	Grammes.	Metres per second.	Milliseconds.	Inches.	Inches.	Grammes.	Grammes.
(A) Forty-per-cent nitroglycerin dynamite	1.22	1221.4	8235	227*	4688	.358	24.63	12	88.4 79.7 14.5	25
(B) FFF black blasting powder	1.25	789.4	4817	374† 458*	469.4‡	.925	54.32	–	154.4 126.9 4.1‖	25
(C) Permissible explosive; nitroglycerin class	1.10	760.5	5912	301*	3008	.471	27.79	4	103.9 65.1 15.4	1000
(D) Permissible explosive; ammonium nitrate class	0.97	992.8	7300	279*	3438§	.483	25.68	1	89.8 27.5 75.5	800
(E) Permissible explosive; hydrated class	1.54	610.6	6597	434*	2479	.338	17.49	3	86.1 56.0 33.0	Over 1000

Chemical Analyses.

(A) Moisture	0.91
Nitroglycerin	39.68
Sodium nitrate	42.46
Wood pulp	13.58
Calcium carbonate	3.37
(B) Moisture	0.80
Sodium nitrate	70.57
Charcoal	17.74
Sulphur	10.89
(C) Moisture	7.89
Nitroglycerin	24.02
Sodium nitrate	36.25
Wood pulp and crude fibre from grains	9.20
Starch	21.31
Calcium carbonate	0.97
Magnesium "	0.36
(D) Moisture	0.23
Ammonium nitrate	83.10
Sulphur	0.46
Starch	2.61
Wood pulp	1.89
Poisonous matter	2.54
Manganese peroxide	2.64
Sand	6.53
(E) Moisture	2.34
Nitroglycerin	30.85
Ammonium nitrate	9.94
Sand	1.75
Coal	11.98
Clay	7.64
Ammonium sulphate	8.96
Zinc sulphate (7HO)	6.89
Potassium sulphate	19.65

* One pound of clay tamping used.
† Two pounds of clay tamping used.
‡ Rate of burning.
§ Cartridges 1½ in. diam.
‖ For 300 grammes.

Compiled from U. S. Geological Survey Results, — " Investigation of Explosives for use in Coal Mines, 1909."

TABLE 204.

HEAT OF

Heat of combination of elements and compounds expressed in units, such that when unit mass of the substance is units, which will be raised in temperature

Substance.	Combined with oxygen forms —	Heat units.	Combined with chlorine forms —	Heat units.	Combined with sulphur forms —	Heat units.	Authority.
Calcium	CaO	3284	$CaCl_2$	4255	CaS	2300	1
Carbon — Diamond	CO_2	7859	–	–	–	–	2
" "	CO	2141	–	–	–	–	3
" — Graphite	CO_2	7796	–	–	–	–	3
Chlorine	Cl_2O	— 254	–	–	–	–	1
Copper	Cu_2O	321	$CuCl$	520	–	–	1
"	CuO	585	$CuCl_2$	819	CuS	158	1
"	"	593	–	–	–	–	4
Hydrogen*	H_2O	34154	HCl	22000	H_2S	2250	3
"	"	34800	–	–	–	–	5
"	"	34417	–	–	–	–	6
Iron	FeO	1353	$FeCl_2$	1464	$FeSH_2O$	428	3
"	–	–	$FeCl_3$	1714	–	–	3
Iodine	I_2O_5	177	–	–	–	–	1
Lead	PbO	243	$PbCl_2$	400	PbS	98	1
Magnesium	MgO	6077	$MgCl_2$	6291	MgS	3191	1
Manganese	$MnOH_2O$	1721	$MnCl_2$	2042	$MnSH_2O_2$	841	1
Mercury	Hg_2O	105	$HgCl$	206	–	–	1
"	HgO	153	$HgCl_2$	310	HgS	84	1
Nitrogen*	N_2O	— 654	–	–	–	–	1
"	NO	—1541	–	–	–	–	1
"	NO_2	— 143	–	–	–	–	1
Phosphorus (red)	P_2O_5	5272	–	–	–	–	1
" (yellow)	"	5747	–	–	–	–	7
" "	"	5964	–	–	–	–	1
Potassium	K_2O	1745	KCl	2705	K_2S	1312	8
Silver	Ag_2O	27	$AgCl$	271	Ag_2S	24	1
Sodium	Na_2O	3293	$NaCl$	4243	Na_2S	1900	8
Sulphur	SO_2	2241	–	–	–	–	1
"	"	2165	–	–	–	–	2
Tin	SnO	573	$SnCl_2$	690	–	–	4
"	–	–	$SnCl_4$	1089	–	–	7
Zinc	ZnO	1185	–	–	–	–	4
"	"	1314	$ZnCl_2$	1495	–	–	1

Substance.	Combined with $S+O_4$ to form —	Heat units.	Combined with $N+O_3$ to form —	Heat units.	Combined with $C+O_3$ to form —	Heat units.	Authority.
Calcium	$CaSO_4$	7997	$Ca(NO_3)_2$	5080	$CaCO_3$	6730	1
Copper	$CuSO_4$	2887	$Cu(NO_3)_2$	1304	–	–	1
Hydrogen	H_2SO_4	96450	HNO_3	41500	–	–	1
Iron	$FeSO_4$	4208	$Fe(NO_3)_2$	2134	–	–	1
Lead	$PbSO_4$	1047	$Pb(NO_3)_2$	512	$PbCO_3$	814	1
Magnesium	$MgSO_4$	12596	–	–	–	–	1
Mercury	–	–	–	–	–	–	1
Potassium	K_2SO_4	4416	KNO_3	3061	K_2CO_3	3583	1
Silver	Ag_2SO_4	776	$AgNO_3$	266	Ag_2CO_3	561	1
Sodium	Na_2SO_4	7119	$NaNO_3$	4834	Na_2CO_3	5841	1
Zinc	$ZnSO_4$	3538	–	–	–	–	1

AUTHORITIES.

1 Thomsen.
2 Berthelot.
3 Favre and Silbermann.
4 Joule.
5 Hess.
6 Average of seven different.
7 Andrews.
8 Woods.

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* Combustion at constant pressure.

TABLE 204 (*continued*).

COMBINATION.

caused to combine with oxygen or the negative radical, the numbers indicate the amount of water, in the same from 0° to 1° C. by the addition of that heat.

Substance.	In dilute solutions.						Authority.
	Forms —	Heat units.	Forms —	Heat units.	Forms —	Heat units.	
Calcium	$CaOH_2O$	3734	$CaCl_2H_2O$	4690	$CaS + H_2O$	2457	1
Carbon — Diamond	–	–	–	–	–	–	2
“ “	–	–	–	–	–	–	3
“ — Graphite	–	–	–	–	–	–	3
Chlorine	–	–	–	–	–	–	1
Copper	–	–	–	–	–	–	1
“	–	–	–	–	–	–	1
“	–	–	–	–	–	–	4
Hydrogen	–	–	–	–	–	–	3
“	–	–	–	–	–	–	5
“	–	–	–	–	–	–	6
Iron	$FeO + H_2O$	1220*	$FeCl_2 + H_2O$	1785	–	–	3
“	–	–	$FeCl_3$	2280	–	–	3
Iodine	–	–	–	–	–	–	1
Lead	–	–	$PbCl_2$	368	–	–	1
Magnesium	MgO_2H_2	9050 †	$MgCl_2$	7779	MgS	4784	1
Manganese	–	–	$MnCl_2$	2327	–	–	1
Mercury	–	–	–	–	–	–	1
“	–	–	$HgCl_2$	299	–	–	1
Nitrogen	–	–	–	–	–	–	1
“	–	–	–	–	–	–	1
“	–	–	–	–	–	–	1
Phosphorus (red)	–	–	–	–	–	–	1
“ (yellow)	–	–	–	–	–	–	7
“ “	–	–	–	–	–	–	1
Potassium	K_2O	2110*	KCl	2592	K_2S	1451	8
Silver	–	–	–	–	–	–	1
Sodium	Na_2O	3375	NaCl	4190	Na_2S	2260	8
Sulphur	–	–	–	–	–	–	1
“	–	–	–	–	–	–	2
Tin	–	–	$SnCl_2$	691	–	–	7
“	–	–	$SnCl_4$	1344	–	–	7
Zinc	–	–	–	–	–	–	4
“	–	–	$ZnCl_2$	1735	–	–	1

Substance.	In dilute solutions.						Authority.
	Forms —	Heat units.	Forms —	Heat units.	Forms —	Heat units.	
Calcium	–	–	$Ca(NO_3)_2$	5175	–	–	1
Copper	$CuSO_4$	3150	$Cu(NO_3)_2$	1310	–	–	1
Hydrogen	H_2SO_4	105300	HNO_3	24550	–	–	1
Iron	$FeSO_4$	4210	$Fe(NO_3)_3$	2134	–	–	1
Lead	–	–	$Pb(NO_3)_2$	475	–	–	1
Magnesium	$MgSO_4$	13420	$Mg(NO_3)_2$	8595	–	–	1
Mercury	–	–	$Hg(NO_3)_2$	335	–	–	1
Potassium	K_2SO_4	4324	KNO_3	2860	–	–	1
Silver	Ag_2SO_4	753	$AgNO_3$	216	–	–	1
Sodium	Na_2SO_4	7160	$NaNO_3$	4620	Na_2CO_3	5995	1
Zinc	$ZnSO_4$	3820	$Zn(NO_3)_2$	2035	–	–	1

AUTHORITIES.

1 Thomsen.	3 Favre and Silbermann.	5 Hess.	7 Andrews.
2 Berthelot.	4 Joule.	6 Average of seven different.	8 Woods.

* Thomsen.

† Total heat from elements.

TABLE 205.

LATENT HEAT OF VAPORIZATION.

The temperature of vaporization in degrees Centigrade is indicated by *T*; the latent heat in large calories per kilogramme or in small calories or therms per gramme by *H*; the total heat from 0° C. in the same units by *H′*. The pressure is that due to the vapor at the temperature *T*.

Substance.	Formula.	*T*	*H*	*H′*	Authority.
Acetic acid	$C_2H_4O_2$	118°	84.9	–	Ogier.
Air	–	–	50.97	–	Fenner-Richtmyer.
Alcohol: Amyl	$C_5H_{12}O$	131	120	–	Schall.
Ethyl	C_2H_6O	78.1	205	255	Wirtz.
"	"	0	236	236	Regnault.
"	"	50	–	264	"
"	"	100	–	267	"
"	"	150	–	285	"
Methyl	CH_4O	64.5	2.67	307	Wirtz.
"	"	0	289	289	Ramsay and Young.
"	"	50	-	274	" " "
"	"	100	–	246	" " "
"	"	150	–	206	" " "
"	"	200	–	152	" " "
"	"	238.5	–	44.2	" " "
Ammonia	NH_3	7.8	294.2	–	Regnault.
"	"	11	291.3	–	"
"	"	16	297.4	–	"
"	"	17	296.5	–	"
Benzene	C_6H_6	80.1	92.9	127.9	Wirtz.
Bromine	Br	61	45.6	–	Andrews.
Carbon dioxide, solid	CO_2	–	–	138.7	Favre.
" " liquid	"	—25	72.23	–	Cailletet and Mathias.
" " "	"	0	57.48	–	" " "
" " "	"	12.35	44.97	–	Mathias.
" " "	"	22.04	31.8	–	"
" " "	"	29.85	14.4	–	"
" " "	"	30.82	3.72	–	"
" disulphide	CS_2	46.1	83.8	94.8	Wirtz.
" "	"	0	90	90	Regnault.
" "	"	100	–	100.5	"
" "	"	140	–	102.4	"
Chloroform	$CHCl_3$	60.9	58.5	72.8	Wirtz.
Ether	$C_4H_{10}O$	34.5	88.4	107	"
"	"	34.9	90.5	–	Andrews.
"	"	0	94	94	Regnault.
"	"	50	–	115.1	"
"	"	120	–	140	"
Iodine	I	–	23.95	–	Favre and Silbermann.
Mercury	Hg	357	65	–	Mean.
Nitrogen	N	—195.6	47.65	–	Alt.
Oxygen	O	—182.9	50.97	–	"
Sulphur dioxide	SO_2	0	91.2	–	Cailletet and Mathias.
" "	"	30	80.5	–	" " "
" "	"	65	68.4	–	" " "
Turpentine	$C_{10}H_{16}$	159.3	74.04	–	Brix.
Water	H_2O	100	535.9	–	Andrews.
"	"	100	–	637	Regnault.

LATENT HEAT OF VAPORIZATION.*

Substance, formula, and temperature.	l = total heat from fluid at 0° to vapor at t°. r = latent heat at t°.	Authority.
Acetone, C_3H_6O, — 3° to 147°.	$l = 140.5 + 0.36644\,t - 0.000516\,t^2$ $l = 139.9 + 0.23356\,t + 0.00055358\,t^2$ $r = 139.9 - 0.27287\,t + 0.0001571\,t^2$	Regnault. Winkelmann. "
Benzene, C_6H_6, 7° to 215°.	$l = 109.0 + 0.24429\,t - 0.0001315\,t^2$	Regnault.
Carbon dioxide, CO_2, — 25° to 31°.	$r^2 = 118.485\,(31 - t) - 0.4707\,(31 - t^2)$	Cailletet and Mathias.
Carbon disulphide, CS_2, — 6° to 143°.	$l = 90.0 + 0.14601\,t - 0.000412\,t^2$ $l = 89.5 + 0.16993\,t - 0.0010161\,t^2 + 0.000003424\,t^3$ $r = 89.5 - 0.06530\,t - 0.0010976\,t^2 + 0.000003424\,t^3$	Regnault. Winkelmann. "
Carbon tetrachloride, CCl_4, 8° to 163°.	$l = 52.0 + 0.14625\,t - 0.000172\,t^2$ $l = 51.9 + 0.17867\,t - 0.0009599\,t^2 + 0.000003733\,t^3$ $r = 51.9 - 0.01931\,t - 0.0010505\,t^2 + 0.000003733\,t^3$	Regnault. Winkelmann. "
Chloroform, $CHCl_3$, — 5° to 159°.	$l = 67.0 + 0.1375\,t$ $l = 67.0 + 0.14716\,t - 0.0000937\,t^2$ $r = 67.0 - 0.08519\,t - 0.0001444\,t^2$	Regnault. Winkelmann. "
Nitrous oxide, N_2O, — 20° to 36°.	$r^2 = 131.75\,(36.4 - t) - 0.928\,(36.4 - t)^2$	Cailletet and Mathias.
Sulphur dioxide, SO_2, 0° to 60°.	$r = 91.87 - 0.3842\,t - 0.000340\,t^2$	Mathias.

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* Quoted from Landolt and Boernstein's "Phys. Chem. Tab." p. 350.

TABLE 206.

LATENT HEAT OF FUSION.

This table contains the latent heat of fusion of a number of solid substances in large calories per kilogramme or small calories or therms per gramme. It has been compiled principally from Landolt and Börnstein's tables. *C* indicates the composition, *T* the temperature Centigrade, and *H* the latent heat.

Substance.	*C*	*T*	*H*	Authority.
Alloys: 30.5Pb + 69.5Sn	$PbSn_4$	183	17.	Spring.
36.9Pb + 63.1Sn	$PbSn_3$	179	15.5	"
63.7Pb + 36.3Sn	PbSn	177.5	11.6	"
77.8Pb + 22.2Sn	Pb_2Sn	176.5	9.54	"
Britannia metal, 9Sn + 1Pb	–	236	28.0*	Ledebur.
Rose's alloy, 24Pb + 27.3Sn + 48.7Bi	–	98.8	6.85	Mazzotto.
Wood's alloy { 25.8Pb + 14.7Sn + 52.4Bi + 7Cd }	–	75.5	8.40	"
Aluminum	Al	658.	76.8	Glaser.
Ammonia	NH_3	—75.	108.	Massol.
Benzole	C_6H_6	5.4	30.6	Mean.
Bromine	Br	—7.3	16.2	Regnault.
Bismuth	Bi	268	12.64	Person.
Cadmium	Cd	320.7	13.66	"
Calcium chloride	$CaCl_2 + 6H_2O$	28.5	40.7	"
Copper	Cu	1083	42.	Mean.
Iron, Gray cast	–		23.	Gruner.
" White "	–	–	33.	"
" Slag	–	–	50.	"
Iodine	I	–	11.71	Favre and Silbermann.
Ice	H_2O	0	79.24	Regnault.
"	"	0	80.02	Bunsen.
" (from sea-water)	{ H_2O + 3.535 of solids }	—8.7	54.0	Petterson.
Lead	Pb	327	5.86	Rudberg.
Mercury	Hg	—39	2.82	Person.
Naphthalene	$C_{10}H_8$	79.87	35.62	Pickering.
Nickel	Ni	1435	4.64	Pionchon.
Palladium	Pd	1545	36.3	Violle.
Phosphorus	P	44.2	4.97	Petterson.
Platinum	Pt	1755	27.2	Violle.
Potassium	K	62	15.7	Joannis.
Potassium nitrate	KNO_3	333.5	48.9	Person.
Phenol	C_6H_6O	25.37	24.93	Petterson.
Paraffin	–	52.40	35.10	Batelli.
Silver	Ag	961	21.07	Person.
Sodium	Na	97	31.7	Joannis.
" nitrate	$NaNO_3$	305.8	64.87	"
" phosphate	{ $Na_2HPO_4 + 12H_2O$ }	36.1	66.8	"
Spermaceti	–	43.9	36.98	Batelli.
Sulphur	S	115	9.37	Person.
Tin	Sn	232	14.0	Mean.
Wax (bees)	–	61.8	42.3	"
Zinc	Zn	419	28.13	"

* Total heat from 0° C.

TABLE 207.

MELTING-POINTS OF THE CHEMICAL ELEMENTS.

The metals in heavier type are often used as standards.

The melting-points are reduced as far as possible to a common temperature scale which is the one used by the United States Bureau of Standards in certifying pyrometers. This scale is defined in terms of Wien's law with C taken as 14000, and on which the melting-point of platinum is 1755° C (Nernst and Wartenburg, 1751; Waidner and Burgess, 1753; Holborn and Valentiner, 1770; see C. R. 148, p. 1177, 1909). Above 1100° C, the temperatures are expressed to the nearest 5° C. Temperatures above the platinum point may be uncertain by over 50° C.

Element.	Melting-point.	Remarks.	Element.	Melting-point.	Remarks.
Aluminum	658 ± 1	Most samples give 657 or less (Burgess).	Manganese	1225	Adjusted.
Antimony	630 ± 1	"Kahlbaum" purity.	Mercury	—39	
Argon	—188	Ramsay-Travers.	Molybdenum	> 2000	Probably.
Arsenic	>Sb, <Ag	Under pressure.	Neodymium	840	(Muthmann-Weiss.)
Barium	850	(Guntz.)	Neon	—252	
Beryllium	<Ag.		**Nickel**	1450	Adjusted (Day-Sosman = 1452).
Bismuth	270	Adjusted.	Niobium	1950	v. Bolton.
Boron	>2000 <2500	Weintraub.	Nitrogen	—211	(Fischer-Alt.)
Bromine	—7.3		Osmium	About 2700	(Waidner - Burgess, unpublished.)
Cadmium	321	Range: 320.7–321.7	Oxygen	—230?	
Cæsium	26	Range: 26.37–25.3	**Palladium**	1545 ± 15	(Waidner-Burgess, Nernst-Wartenburg.)
Calcium	805	Adjusted.	Phosphorus	44.2	
Chlorine	—102	(Olszewski.)	**Platinum**	1755 ± 20	See Note.
Carbon	(> 3500)	Sublimes.	Potassium	62.5	
Cerium	623	(Muthmann-Weiss.)	Præsodymium	940	(Muthmann-Weiss.)
Chromium	1505	Adjusted.	Rhodium	1910	(Mendenhall-Ingersoll.)
Cobalt	1490	Day-Sosman.	Rubidium	38.5	
Copper	1083 ± 3	Mean, Holborn-Day, Day-Clement.	Ruthenium	1900?	
Erbium			Samarium	1300–1400	(Muthmann-Weiss.)
Fluorine	—223	(Moissan - Dewar.)	Silicon	1420	Adjusted.
Gallium	30.1		**Silver**	961 ± 1	Adjusted.
Germanium	< Ag		Sodium	97	
Gold	1063 ± 3	Adjusted.	Strontium		Between Ca and Ba?
Hydrogen	—259		Sulphur	113.5–119.5	Various forms. See Landolt-Börnstein.
Indium	155	(Thiel.)	Tantalum	2800	Adjusted from Waidner-Burgess = 2910.
Iodine	114	Range: 112–115.	Tellurium	451	Adjusted.
Iridium	>2250 <2300	Adjusted.	Thallium	301	
Iron	1520	Adjusted.	Thorium	>1700<Pt	v. Wartenburg.
Krypton	—169	(Ramsay.)	**Tin**	231.9 ± .2	
Lanthanum	810	(Muthmann-Weiss.)	Titanium	?	Above 2000?
Lead	327 ± 0.5		Tungsten	2950	Mean, Waidner-Burgess and Wartenburg.
Lithium	186	(Kahlbaum.)	Uranium	Near Mo	Moissan.
Magnesium	651	(Grube) in clay crucibles, 635.	Vanadium	1750	Vogel-Tammann.
			Xenon	—140	Ramsay.
			Zinc	419 ± 0.5	
			Zirconium	> Si	Troost.

TABLE 208.

BOILING-POINTS OF THE CHEMICAL ELEMENTS.

Element.	Range.	Boiling-point.	Observer; Remarks.
	°	°	
Aluminum	–	1800.	Greenwood, Ch. News, 100, 1909.
Antimony	–	1440.	" " " " "
Argon	–	—186.1	Ramsay-Travers, Z. Phys. Ch. 38, 1901.
Arsenic	449–450	–	Gray, sublimes, Conechy.
"	–	>360.	Black, sublimes, Engel, C. R. 96, 1883.
"	280–310	–	Yellow, sublimes.
Barium	–	–	Boils in vacuo, Guntz, 1903.
Bismuth	1420–1435	1430.	Barus, 1894; Greenwood, l. c.
Boron	–	–	Volatilizes without melting in electric arc.
Bromine	59–63	61.1	Thorpe, 1880; van der Plaats, 1886.
Cæsium	–	670.	Ruff-Johannsen.
Carbon	–	3600.	Computed, Violle, C. R. 120, 1895.
"	–	–	Volatilizes without melting in electric oven, Moisson.
Cadmium	760–782	770.	
Chlorine	–	—33.6	Regnault, 1863.
Chromium	–	2200.	Greenwood, Ch. News, 100, 1909.
Copper	2100–2310	2310.	" l. c.
Fluorine	–	—187.	Moisson-Dewar, C. R. 136, 1903.
Helium	–	—267.	Computed, Tracers, Ch. News, 86, 1902.
Hydrogen	—252.5–252.8	—252.6	Mean.
Iodine	–	>200.	
Iron	–	2450.	Greenwood, l. c.
Krypton	–	—151.7	Ramsay, Ch. News, 87, 1903.
Lead	–	1525.	Greenwood, l. c.
Lithium	–	1400.	Ruff-Johannsen, Ch. Ber. 38, 1905.
Magnesium	–	1120.	Greenwood, l. c.
Manganese	–	1900.	" "
Mercury	–	357.	Crafts; Regnault.
Nitrogen	—195.7–194.4	—195.	Mean.
Oxygen	—182.5–182.9	—182.7	"
Ozone	–	—119.	Troost, C. R. 126, 1898.
Phosphorus	287–290	288.	
Potassium	667–757	712.	Perman; Ruff-Johannsen.
Rubidium	·	696.	Ruff-Johannsen.
Selenium	664–694	690.	
Silver	–	1955.	Greenwood, l. c.
Sodium	742–757	750.	Perman; Ruff-Johannsen.
Sulphur	444.7–445	444.7	Mean.
Tellurium	–	1390.	Deville-Troost, C. R. 91, 1880.
Thallium	1600–1800	1700.	
Tin		2270.	Greenwood, l. c.
Xenon	–	—109.1	Ramsay, Z. Phys. Ch. 44, 1903.
Zinc	916–942	930.	

TABLE 209.

MELTING-POINTS OF VARIOUS INORGANIC COMPOUNDS.*

Substance.	Chemical Formula.	Melting-point. Min.	Melting-point. Max.	Melting-point. Particular or Average Value.	Authority.	Date of Publication.
Aluminum chloride	$AlCl_3$	–	–	190.	1	1888
“ nitrate	$Al(NO_3)_3 + 9H_2O$	–	–	72.8	2	1859
Ammonia	NH_3	–	–	—75.	3	1875
Ammonium nitrate	NH_4NO_3	145.	166.	156.	–	–
“ sulphate	$(NH_4)_2SO_4$	–	–	140.	4	1837
“ phosphite	$NH_4H_2PO_3$	–	–	123.	5	1887
Antimonietted hydrogen	SbH_3	–	–	—91.5	6	1886
Antimony trichloride	$SbCl_3$	72.	73.2	72.8	–	–
“ pentachloride	$SbCl_5$	–	–	—6.	7	1875
Arsenic trichloride	$AsCl_3$	–	–	—18.	8	1903
Arsenietted hydrogen	AsH_3	–	–	—113.5	6	1884
Barium chlorate	$Ba(ClO_3)_2$	–	–	414.	9	1878
“ nitrate	$Ba(NO_3)_2$	–	–	593.	9	1878
“ perchlorate	$Ba(ClO_4)_2$	–	–	505.	10	1884
Bismuth trichloride	$BiCl_3$	225.	230.	227.5	11	1876
Boric acid	H_3BO_3	184.	186.	185.	9	1878
“ anhydride	B_2O_3	–	–	577.	9	1878
Borax (sodium borate)	$Na_2B_4O_7$	–	878.	561.	9	1878
Cadmium chloride	$CdCl_2$	–	590.	541.	9	1878
“ nitrate	$Cd(NO_3)_2 + 4H_2O$	–	–	59.5	2	1859
Calcium chloride	$CaCl_2$	719.	806.	762.	–	–
“ “	$CaCl_2 + 6H_2O$	–	–	29.6	–	–
“ nitrate	$Ca(NO_3)_2$	499.	–	561.	9	1878
“ “	$Ca(NO_3)_2 + 4H_2O$	–	–	44.	2	1859
Carbon tetrachloride	CCl_4	–	–	—24.7	12	1863
“ trichloride	C_2Cl_6	182.	187.	184.5	–	–
“ monoxide	CO	—199.	—207.	203.		–
“ dioxide	CO_2	—56.5	—57.5	—57.	3	1845
“ disulphide	CS_2	–	–	—112.8	14	1903
Chloric acid	$HClO_4 + H_2O$	–	–	50.	15	1861
Chlorine dioxide	ClO_2	–	–	—76.	3	1845
Chrome alum	$KCr(SO_4)_2 + 12H_2O$	–	–	89.	16	1884
“ nitrate	$Cr_2(NO_3)_6 + 18H_2O$	–	–	37.	2	1859
Cobalt sulphate	$CoSO_4$	96.	98.	97.	16	1884
Cupric chloride	$CuCl_2$	–	–	498.	9	1878
Cuprous “	Cu_2Cl_2	–	–	434.	9	1878
“ nitrate	$Cu(NO_3)_2 + 3H_2O$	–	–	114.5	2	1859
Hydrobromic acid	HBr	–	–	—86.7	3	1845
Hydrochloric “	HCl	–	–	—111.3	17	1900
Hydrofluoric “	HFl	–	–	—92.3	6	1886
Hydroiodic “	HI	49.5	51.3	51.3	17	1900
Hydrogen peroxide	H_2O_2	–	–	—2.	18	–
“ phosphide	PH_3	–	–	—132.5	6	1886
“ sulphide	H_2S	–	–	—85.6	3	1845
Iron chloride	$FeCl_3$	301.	307.	303.	–	–
“ nitrate	$Fe(NO_3)_3 + 9H_2O$	–	–	47.2	2	1859
“ sulphate	$FeSO_4 + 7H_2O$	–	–	64.	16	1884
Lead chloride	$PbCl_2$	447.	580.	506.	–	–
“ metaphosphate	$Pb(PO_3)_2$	–	–	800.	9	1878
Magnesium chloride	$MgCl_2$	–	–	708.	9	1878
“ nitrate	$Mg(NO_3)_2 + 6H_2O$	–	–	90.	2	1859
“ sulphate	$MgSO_4 + 5H_2O$	–	–	54.	16	1884
Manganese chloride	$MnCl_2 + 4H_2O$	–	–	87.5	19	–
“ nitrate	$Mn(NO_3)_2 + 6H_2O$	–	–	25.8	2	1859
“ sulphate	$MnSO_4 + 5H_2O$	–	–	54.	16	1884
Mercuric chloride	$HgCl_2$	287.	293.	290.	–	–

1 Friedel & Crafts.
2 Ordway.
3 Faraday.
4 Marchand.
5 Amat.
6 Olszewski.
7 Kammerer.
8 Baskerville.
9 Carnelley.
10 Carnelley & O'Shea.
11 Muir.
12 Regnault.
13 Wroblewski & Olszewski.
14 Holborn & Wien.
15 Roscoe.
16 Tilden.
17 Ladenburg.
18 Staedel.
19 Clarke, “Const. of Nat.”

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*For more extensive tables on this subject, see Carnelley's “Melting and Boiling-point Tables,” or Landolt and Börnstein's “Phys. Chem. Tab.”

TABLE 209 (*continued*).

MELTING-POINTS OF VARIOUS INORGANIC COMPOUNDS.

Substance.	Chemical Formula.	Melting-point. Min.	Melting-point. Max.	Melting-point. Particular or Probable Value.	Authority	Date of Publication.
Nickel carbonyl	$NiCO_4$	–	–	—25.	1	1890
" nitrate	$Ni(NO_3)_2 + 6H_2O$	–	–	56.7	2	1859
" sulphate	$NiSO_4 + 7H_2O$	98.	100.	99.	3	1884
Nitric acid	HNO_3	–	–	—47.	4	1878
" anhydride	N_2O_5	–	–	30.	5	1872
" oxide *	NO	150.	–	—167.	6	1885
" peroxide	N_2O_4	—9.	—12.	—10.6	–	–
Nitrous anhydride . . .	N_2O_3	–	–	—82.	7	1889
" oxide	N_2O	–	–	—102.3	8	1893
Phosphoric acid (ortho) .	H_3PO_4	38.6	41.7	40.3	–	–
Phosphorous acid . . .	H_3PO_3	70.1	74.	72.	–	–
Phosphorus trichloride .	PCl_3	–	–	111.8	10	1883
" oxychloride .	$POCl_3$	–	–	—1.5	11	1871
" disulphide . .	P_3S_6	296.	298.	297.	12	1879
" pentasulphide	P_2S_5	274.	276.	275.	13	1879
" sesquisulphide	P_4S_3	142.	167.	158.	–	–
" trisulphide .	P_2S_3	–	–	290.	14	1864
Potassium carbonate . .	K_2CO_3	834.	897.	840.	–	–
" chlorate . . .	$KClO_3$	334.	372.	360.	–	–
" perchlorate . .	$KClO_4$	–	–	610.	15	1880
" chloride . . .	KCl	740.	804.	779.	–	–
" nitrate . . .	KNO_3	327.	353.	340.	–	–
" acid phosphate	KH_2PO_4	–	–	96.	3	1884
" acid sulphate .	$KHSO_4$	–	–	200.	16	1840
Silver chloride	$AgCl$	450.	460.	455.	–	–
" nitrate	$AgNO_3$	198.	224.	214.	–	–
" nitrogeniętted . .	AgN_3	–	–	250.	17	1890
" perchlorate . . .	$AgClO_4$	–	–	486.	18	1884
" phosphate	Ag_3PO_4	–	–	849.	15	1878
" metaphosphate . .	$AgPO_3$	–	–	482.	15	1878
" sulphate	Ag_2SO_4	654.	676.	665.	–	–
Sodium chloride	$NaCl$	772.	820.	795.	–	–
" hydroxide . . .	$NaOH$	–	–	60.	19	1884
" nitrate	$NaNO_3$	308.	330.	315.	–	–
" chlorate	$NaClO_3$	248.	302.	275.	–	–
" perchlorate . . .	$NaClO_4$	–	–	482.	18	1884
" carbonate . . .	Na_2CO_3	814.	920.	852.	–	–
" "	$Na_2CO_3 + 10H_2O$	–	–	34.	3	1884
" phosphate . . .	$Na_2HPO_4 + 4H_2O$	35.	36.4	35.4	–	–
" metaphosphate .	$NaPO_3$	–	–	617.	15	1878
" pyrophosphate .	$Na_4P_2O_7$	888.	970.	938.	–	–
" phosphite . . .	$(H_2NaPO_3)_2 + 5H_2O$	–	–	42.	20	1888
" sulphate . . .	Na_2SO_4	861.	865.	863.	15	1878
" "	$Na_2SO_4 + 10H_2O$	–	–	34.	3	1884
" hyposulphite . .	$Na_2S_2O_3 + 5H_2O$	45.	48.1	47.	–	–
Sulphur dioxide	SO_2	73.	79.	76.	–	–
Sulphuric acid	H_2SO_4	10.1	10.6	10.4	21	1884
" "	$12H_2SO_4 + H_2O$	–	–	—0.5	22	1853
" "	$H_2SO_4 + H_2O$	7.5	8.5	8.	–	–
" " (pyro) . . .	$H_2S_2O_7$	–	–	35.	22	1853
Sulphur trioxide	SO_3	14.8	15.	14.9	5	1876–1886
Tin, stannic chloride . .	$SnCl_4$	–	–	—33.	23	1889
" stannous " . . .	$SnCl_2$	–	–	250.	24	–
Zinc chloride	$ZnCl_2$	–	–	262.	25	1875
" "	$ZnCl_2 + 3H_2O$	–	–	6.5	26	1904
" nitrate	$Zn(NO_3)_2 + 6H_2O$	–	–	36.4	3	1884
" sulphate	$ZnSO_4 + 7H_2O$	–	–	50.	3	1884

1 Mond, Langer & Quincke.
2 Ordway.
3 Tilden.
4 Berthelot.
5 R. Weber.
6 Olszewski.
7 Birhaus.
8 Ramsay.
9 Wills.
10 Wroblewski & Olszewski.
11 Genther & Michaelis.
12 Ramme.
13 V. & C. Meyer.
14 Lemoine.
15 Carnelley.
16 Mitscherlich.
17 Curtius.
18 Carnelley & O'Shea.
19 Cripps.
20 Amat.
21 Mendelejeff.
22 Marignac.
23 Besson.
24 Clarke, "Const. of Nat."
25 Braun.
26 Mylius.

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* Under pressure 138 mm. mercury.

TABLE 210.

BOILING-POINTS OF INORGANIC COMPOUNDS.*

Substance.	Chemical Formula.	Boiling-point. Min.	Boiling-point. Max	Boiling-point. Particular or Average Values.	Authority.	Date of Publication.
Air †	–	–	–	—192.2	1	1884
"	–	–	–	—191.4	2	1884
Aluminum chloride ‡	$AlCl_3$	–	–	207.5	3	1888
" nitrate	$Al(NO_3)_3+9H_2O$	–	–	134.	4	1859
Ammonia	NH_3	–	–	—38.5	5	1863
Antimonietted hydrogen	SbH_3	–	–	—18.	2	1886
Antimony pentachloride §	$SbCl_5$	102.	103.	–	6	1889
" trichloride	$SbCl_3$	216.	223.5	220.	–	–
Bismuth trichloride	$BiCl_3$	427.	447.	435.	5, 7	–
Cadmium chloride	$CdCl_2$	861.	954.	908.	8	1880
" nitrate	$Cd(NO_3)_2+4H_2O$	–	–	132.	4	1859
Calcium nitrate	$Ca(NO_3)_2+4H_2O$	.	–	132.	4	1859
Carbon dioxide	CO_2	—78.2	—80.	—79.1	–	1863–1880
" disulphide	CS_2	46.	47.4	46.1	–	–
" monoxide	CO	190.	—193.	—191.5	2, 1	1884
Chromic oxychloride	CrO_2Cl_2	115.9	118.	117.	–	–
Chromium nitrate	$Cr_2(NO_3)_6+18H_2O$	–	–	125.5	4	1859
Copper nitrate	$Cu(NO_3)_2+3H_2O$	–	–	170.	4	1859
Cuprous chloride	Cu_2Cl_2	954.	1032.	993.	8	1880
Hydrobromic acid ‖	HBr	–	–	—68.1	9	1900
Hydrochloric acid ‖	HCl	–	–	—83.1	9	1900
Hydrofluoric acid ‖	HF	–	–	—36.7	9	1900
Hydroiodic acid	HI	–	–	127.	10	1870
Iron nitrate	$Fe(NO_3)_3+9H_2O$	–	–	125.	4	1859
Magnesium nitrate	$Mg(NO_3)_2+6H_2O$	–	–	143.	4	1859
Manganese chloride	$MnCl_2+4H_2O$	–	–	106.	11	–
" nitrate	$Mn(NO_3)_2+6H_2O$	–	–	129.5	4	1859
Mercuric chloride	$HgCl_2$	302.	307.	304.	–	–
Nickel nitrate	$Ni(NO_3)_2+6H_2O$	–	–	136.7	4	1859
Nitric acid	HNO_3	–	–	86.	12	1830
" anhydride	N_2O_5	45.	50.	–	13	1849
" oxide	NO	–	–	—153.	2	1885
Nitrous anhydride	N_2O_3	—10.	3.5	–	–	–
" oxide	N_2O	—87.9	89.8	88.8	–	–
Phosphorus trichloride	PCl_3	73.8	76.	75.	–	–
" sesquisulphide	P_4S_3	–	–	380.	14	1883
" trisulphide	P_2S_3	–	–	490.	14	1886
" pentasulphide	P_2S_5	518.	530.	522.	–	–
" trioxide	P_2O_3	–	–	173.	15	1890
Silicon chloride	$SiCl_4$	56.8	59.	58.	–	–
Sulphuric acid	$12H_2SO_4+H_2O$	–	–	338.	16	1853
Sulphur trioxide	SO_3	46.	47.	46.3	–	–
" dioxide	SO_2	—8.	—10.5	—9.6	–	–
" chloride	S_2Cl_2	138.	144.	139.	–	–
Tin, stannous chloride	$SnCl_2$	606.	628.	617.	–	–
" stannic "	$SnCl_4$	–	–	113.9	17	1876
Zinc chloride	$ZnCl_2$	676.	730.	703.	–	–
" nitrate	$Zn(NO_3)_2+6H_2O$	–	–	131.	4	1859

1 Wroblewski.
2 Olszewski.
3 Friedel and Crafts.
4 Ordway.
5 Regnault.
6 Anschütz and Evans.
7 Pictet.
8 Carnelley and Carleton-Williams.
9 Ladenburg and Krügel.
10 Topsöe.
11 Clarke, "Const. of Nature."
12 Mitscherlich.
13 Deville.
14 Isambert.
15 Thorpe and Tutton.
16 Marignac.
17 Thorpe.

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* For a more complete table, see Landolt-Börnstein-Meyerhoffer's Physikalisch-chemische Tabellen.
† Pressure 76 cm. ‡ Pressure 2.64 atmos. § Pressure 68 mm. ‖ Pressure 75.5 cm.

TABLE 211.—Melting-point of Mixtures.

Metals.	Melting-points, C°.											Reference.
	Percentage of metal in second column.											
	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	
Pb. Sn.	326	290	270	250	230	215	200	180	190	210	232	1
Bi.	322	290	–	–	179	145	126	168	205	–	268	7
Te.	322	710	790	880	917	760	600	480	410	425	446	8
Ag.	328	460	545	590	620	650	705	775	840	905	959	9
Na.	–	360	420	400	370	330	290	250	200	130	96	13
Cu.	326	930	953	953	953	953	953	975	1010	1045	1081	2
Sb.	326	250	275	330	395	440	490	525	560	600	632	16
Al. Sb.	650	750	840	925	945	950	970	1000	1040	1010	632	17
Cu.	650	630	600	560	540	580	610	755	930	1055	1084	18
Au.	655	675	740	800	855	915	970	1025	1055	675	1062	10
Ag.	650	625	615	600	590	580	575	570	650	750	954	17
Zn.	654	640	620	600	580	560	530	510	475	425	419	11
Fe.	654	635	630	1125	1170	1200	1350	1450	1520	1570	1600	3
Sn.	650	645	635	625	620	605	590	570	560	540	232	17
Sb. Bi.	632	610	590	575	555	540	520	470	405	330	268	16
Ag.	630	595	570	545	520	500	505	545	680	850	959	9
Sn.	622	600	570	525	480	430	395	350	310	255	232	19
Zn.	632	555	510	540	570	565	540	525	510	470	419	17
Ni. Sn.	1455	1380	1290	1200	1235	1290	1305	1230	1060	800	232	17
Na. Bi.	96	425	520	590	645	690	720	730	715	570	268	13
Cd.	96	125	185	245	285	325	330	340	360	390	322	13
Cd. Ag.	322	420	520	610	700	760	805	850	895	940	954	17
Tl.	321	300	285	270	262	258	245	230	210	235	302	14
Zn.	322	280	270	295	313	327	340	355	370	390	419	11
Au. Cu.	1063	940	910	925	943	968	993	1018	1040	1060	1083	4
Ag.	1064	1062	1061	1058	1054	1049	1039	1025	1006	982	963	5
Pt.	1075	1125	1190	1250	1320	1380	1455	1530	1610	1685	1775	20
K. Na.	62	17.5	—10	—3.5	5	11	26	41	58	77	97.5	15
Hg.	–	–	–	–	–	90	110	135	162	265	–	13
Tl.	62.5	133	165	188	205	215	220	240	280	305	301	14
Cu. Ni.	1080	1180	1240	1290	1320	1335	1380	1410	1430	1440	1455	17
Ag.	1082	1035	990	945	910	870	830	788	814	875	960	9
Sn.	1084	1005	890	755	725	680	630	580	530	440	232	12
Zn.	1084	1055	1000	945	890	870	840	785	700	570	419	6
Ag. Zn.	959	850	755	705	690	660	630	610	570	505	419	11
Sn.	959	870	750	630	550	495	450	420	375	300	232	9
Na. Hg.	96.5	90	80	70	60	45	22	55	95	215	–	13

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TABLE 212.—Alloy of Lead, Tin, and Bismuth.

	Per cent.									
Lead	32.0	25.8	25.0	43.0	33.3	10.7	50.0	35.8	20.0	70.9
Tin	15.5	19.8	15.0	14.0	33.3	23.1	33.0	52.1	60.0	9.1
Bismuth . . .	52.5	54.4	60.0	43.0	33.3	66.2	17.0	12.1	20.0	20.0
Solidification at	96°	101°	125°	128°	145°	148°	161°	181°	182°	234°

Charpy, Soc. d'Encours, Paris, 1901.

TABLE 213.—Low Melting-point Alloy.

	Per cent.						
Cadmium . .	10.8	10.2	14.8	13.1	6.2	7.1	6.7
Tin	14.2	14.3	7.0	13.8	9.4	–	–
Lead	24.9	25.1	26.0	24.3	34.4	39.7	43.4
Bismuth . . .	50.1	50.4	52.2	48.8	50.0	53.2	49.9
Solidification at	65.5°	67.5°	68.5°	68.5°	76.5°	89.5°	95°

Drewitz, Diss. Rostock, 1902.

All compiled from Landolt-Börnstein-Meyerhoffer's Physikalisch-chemische Tabellen.

TABLE 214.

DENSITIES, MELTING-POINTS, AND BOILING-POINTS OF SOME ORGANIC COMPOUNDS.

N.B. — The data in this table refer only to normal compounds.

Substance.	Formula	Temp. ° C.	Density.	Melting-point	Boiling-point.	Authority.
(a) Paraffin Series: C_nH_{2n+2}.						
Methane*	CH_4	−164.	0.415	-	−165.	Olszewski, Young.
Ethane†	C_2H_6	0	.446	−171.4	−93.	Ladenburg, "
Propane	C_3H_8	0	.536	-	−45.	Young, Hainlen.
Butane	C_4H_{10}	0	.60	-	1.	Butlerow, Young.
Pentane	C_5H_{12}	0	.647	-	36.3	Thorpe, Young.
Hexane	C_6H_{14}	17.	.663	-	69.	Schorlemmer.
Heptane	C_7H_{16}	0	.701	-	98.4	Thorpe, Young.
Octane	C_8H_{18}	0	.719	-	125.5	" "
Nonane	C_9H_{20}	0	.733	−51.	150.	Krafft.
Decane	$C_{10}H_{22}$	0	.745	−31.	173.	"
Undecane	$C_{11}H_{24}$	0	.756	−26.	195.	"
Dodecane	$C_{12}H_{26}$	0	.765	−12.	214.	"
Tridecane	$C_{13}H_{28}$	0	.771	−6.	234.	"
Tetradecane	$C_{14}H_{30}$	4.	.775	5.	252.	"
Pentadecane	$C_{15}H_{32}$	10.	.776	10.	270.	"
Hexadecane	$C_{16}H_{34}$	18.	.775	18.	287.	"
Heptadecane	$C_{17}H_{36}$	22.	.777	22.	303.	"
Octadecane	$C_{18}H_{38}$	28.	.777	28.	317.	"
Nonadecane	$C_{19}H_{40}$	32.	.777	32.	330.	"
Eicosane	$C_{20}H_{42}$	37.	.778	37.	121.§	"
Heneicosane	$C_{21}H_{44}$	40.	.778	40.	129.§	"
Docosane	$C_{22}H_{46}$	44.	.778	44.	136.5§	"
Tricosane	$C_{23}H_{48}$	48.	.779	48.	142.5§	"
Tetracosane	$C_{24}H_{50}$	51.	.779	51.	243.‡	"
Heptacosane	$C_{27}H_{56}$	60.	.780	60.	172.§	"
Pentriacontane	$C_{31}H_{64}$	68.	.781	68.	199.§	"
Dicetyl	$C_{32}H_{66}$	70.	.781	70.	205.§	"
Penta-tria-contane	$C_{35}H_{72}$	75.	.782	75.	331.‡	"
(b) Olefines, or the Ethylene Series: C_nH_{2n}.						
Ethylene	C_2H_4	-	0.610	−169.	−103.	Wroblewski or Olszewski.
Propylene	C_3H_6	-	-	-	−50.2	Ladenburg, Krügel.
Butylene	C_4H_8	−13.5	.635	-	1.	Sieben.
Amylone	C_5H_{10}	-	-	-	36.	Wagner or Saytzeff.
Hexylene	C_6H_{12}	0	.76	-	69.	Wreden or Znatowicz.
Heptylene	C_7H_{14}	19.5	.703	-	96.–99.	Morgan or Schorlemmer.
Octylene	C_8H_{16}	17.	.722	-	122.–123.	Möslinger.
Nonylene	C_9H_{18}	20.	.767	-	140.–142.	Beilstein, "Org. Chem."
Decylene	$C_{10}H_{20}$	-	-	-	175.	" " "
Undecylene	$C_{11}H_{22}$	20.	.773	-	196.–197.	" " "
Dodecylene	$C_{12}H_{24}$	−31.	.795	−31.	212.–214.	" " "
Tridecylene	$C_{13}H_{26}$	15.	.774	-	233.	Bernthsen.
Tetradecylene	$C_{14}H_{28}$	−12.	.794	−12.	127.‡	Krafft.
Pentadecylene	$C_{15}H_{30}$	-	.814	-	247.	Bernthsen.
Hexadecylene	$C_{16}H_{32}$	4.	.792	4.	155.‡	Krafft, Mendelejeff, etc.
Octadecylene	$C_{18}H_{36}$	18.	.791	18.	179.‡	Krafft.
Eicosylene	$C_{20}H_{40}$	0	.871	-	390.–400.	Beilstein, "Org. Chem."
Cerotene	$C_{27}H_{54}$	-	-	58.	-	Bernthsen.
Melene	$C_{30}H_{60}$	-	-	62.	-	"

* Liquid at −11.° C. and 180 atmospheres' pressure (Cailletet).
† " " + 4.° " " 46 " " "
‡ Boiling-point under 15 mm. pressure.
§ In vacuo.

TABLE 214 (*continued*).

DENSITIES, MELTING-POINTS, AND BOILING-POINTS OF SOME ORGANIC COMPOUNDS.

Substance.	Chemical formula.	Temp. C°.	Specific gravity.	Melting-point.	Boiling-point.	Authority.
(c) Acetylene Series: C_nH_{2n-2}.						
Acetylene	C_2H_2	–	–	—81.	—85.	Villard.
Allylene	C_3H_4	–	–	–	–	
Ethylacetylene . . .	C_4H_6	–	–	–	+ 18.	Bruylants, Kutscheroff, and others.
Propylacetylene . . .	C_5H_8	–	–	–	48.–50.	Bruylants, Taworski.
Butylacetylene . . .	C_6H_{10}	–	–	–	68.–70.	Taworski.
Oenanthylidene . . .	C_7H_{12}	–	–	–	100.–101.	Beilstein, and others.
Caprylidene	C_8H_{14}	0.	0.771	–	133.–134.	Behal.
Undecylidene	$C_{11}H_{20}$	–	–	–	210.–215.	Bruylants.
Dodecylidene . . .	$C_{12}H_{22}$	—9.	.810	—9.	105.*	Krafft.
Tetradecylidene . . .	$C_{14}H_{26}$	+ 6.5	.806	+ 6.5	134.*	"
Hexadecylidene . . .	$C_{16}H_{30}$	20.	.804	20.	160.*	"
Octadecylidene . . .	$C_{18}H_{34}$	30.	.802	30.	184.*	"
(d) Monatomic alcohols: $C_nH_{2n+1}OH$.						
Methyl alcohol . . .	CH_3OH	0.	0.812	–	66.	
Ethyl alcohol	C_2H_5OH	0.	.806	—130.†	78.	
Propyl alcohol . . .	C_3H_7OH	0.	.817	–	97.	From Zander, "Lieb. Ann." vol. 224, p. 85, and Krafft, "Ber." vol. 16, 1714, " 19, 2221, " 23, 2360, and also Wroblewski and Olszewski, "Monatshefte," vol. 4, p. 338.
Butyl alcohol	C_4H_9OH	0.	.823	–	117.	
Amyl alcohol	$C_5H_{11}OH$	0.	.829	–	138.	
Hexyl alcohol . . .	$C_6H_{13}OH$	0.	.833	–	157.	
Heptyl alcohol . . .	$C_7H_{15}OH$	0.	.836	–	176.	
Octyl alcohol	$C_8H_{17}OH$	0.	.839	–	195.	
Nonyl alcohol . . .	$C_9H_{19}OH$	0.	.842	—5.	213.	
Decyl alcohol . . .	$C_{10}H_{21}OH$	+ 7.	.839	+ 7.	231.	
Dodecyl alcohol . . .	$C_{12}H_{25}OH$	24.	.831	24.	143.*	
Tetradecyl alcohol . .	$C_{14}H_{29}OH$	38.	.824	38.	167.*	
Hexadecyl alcohol . .	$C_{16}H_{33}OH$	50.	.818	50.	190.*	
Octadecyl alcohol . .	$C_{18}H_{37}OH$	59.	.813	59.	211.*	
(e) Alcoholic ethers: $C_nH_{2n+2}O$.						
Dimethyl ether . . .	C_2H_6O	–	–	–	—23.6	Erlenmeyer, Kreichbaumer.
Diethyl ether	$C_4H_{10}O$	4.	0.731	—117	+ 34.6	Regnault, Olszewski.
Dipropyl ether . . .	$C_6H_{14}O$	0.	.763	–	90.7	Zander and others.
Di-iso-propyl ether . .	$C_6H_{14}O$	0.	.743	–	69.	"
Di-n-butyl ether . . .	$C_8H_{18}O$	0.	.784	–	141.	Lieben, Rossi, and others.
Di-sec-butyl ether . .	$C_8H_{18}O$	21.	.756	–	121.	Kessel.
Di-iso-butyl " . .	$C_8H_{18}O$	15.	.762	–	122.	Reboul.
Di-iso-amyl " . .	$C_{10}H_{22}O$	0.	.799	–	170.–175.	Wurtz.
Di-sec-hexyl " . .	$C_{12}H_{26}O$	–	–	–	203.–208.	Erlenmeyer and Wanklyn.
Di-norm-octyl " . .	$C_{16}H_{34}O$	17.	.805	–	280.–282.	Moslinger.
(f) Ethyl ethers: $C_nH_{2n+2}O$.						
Ethyl-methyl ether . .	C_3H_8O	0.	0.725	–	11.	Wurtz, Williamson.
" propyl " . .	$C_5H_{12}O$	20.	0.739	–	63.–64.	Chancel, Brühl.
" iso-propyl ether .	$C_5H_{12}O$	0.	.745	–	54.	Markownikow.
" norm-butyl ether	$C_6H_{14}O$	0.	.769	–	92.	Lieben, Rossi.
" iso-butyl ether .	$C_6H_{14}O$	–	.751	–	78.–80.	Wurtz.
" iso-amyl ether .	$C_7H_{16}O$	18.	.764	–	112.	Williamson and others.
" norm-hexyl ether	$C_8H_{18}O$	–	–	–	134.–137.	Lieben, Janeczek.
" norm-heptyl ether	$C_9H_{20}O$	16.	.790	–	165.	Cross.
" norm-octyl ether	$C_{10}H_{22}O$	17.	.794	–	182.–184.	Moslinger.

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* Boiling-point under 15 mm. pressure.

† Liquid at —11.° C. and 180 atmospheres' pressure (Cailletet).

TABLE 215.

LOWERING OF FREEZING-POINTS BY SALTS IN SOLUTION.

In the first column is given the number of gramme-molecules (anhydrous) dissolved in 1000 grammes of water; the second contains the molecular lowering of the freezing-point; the freezing-point is therefore the product of these two columns. After the chemical formula is given the molecular weight, then a reference number.

$\frac{\text{g. mol.}}{1000 \text{ g. } H_2O}$	Molecular Lowering.
$Pb(NO_3)_2$, 331.0: 1, 2.	
0.000362	5.5°
.001204	5.30
.002805	5.17
.005570	4.97
.01737	4.69
.5015	2.99
$Ba(NO_3)_2$, 261.5: 1.	
0.000383	5.6°
.001259	5.28
.002681	5.23
.005422	5.13
.008352	5.04
$Cd(NO_3)_2$, 236.5: 3.	
0.00298	5.4°
.00689	5.25
.01997	5.18
.04873	5.15
$AgNO_3$, 167.0: 4, 5.	
0.1506	3.32°
.5001	2.96
.8645	2.87
1.749	2.27
2.953	1.85
3.856	1.64
0.0560	3.82
.1401	3.58
.3490	3.28
KNO_3, 101.9: 6, 7.	
0.0100	3.5
.0200	3.5
.0500	3.41
.100	3.31
.200	3.19
.250	3.08
.500	2.94
.750	2.81
1.000	2.66
$NaNO_3$, 85.09: 2, 6, 7.	
0.0100	3.6°
.0250	3.46
.0500	3.44
.2000	3.345
.500	3.24
.5015	3.30
1.000	3.15
1.0030	3.03
NH_4NO_3, 80.11: 6, 8.	
0.0100	3.6°
.0250	3.50
0.0500	3.47°
.1000	3.42
.2000	3.32
.500	3.26
1.000	3.14
$LiNO_3$, 69.07: 9.	
0.0398	3.4°
.1671	3.35
.4728	3.35
1.0164	3.49
$Al_2(SO_4)_3$, 342.4: 10.	
0.0131	5.6°
.0261	4.9
.0543	4.5
.1086	4.03
.217	3.83
$CdSO_4$, 208.5: 1, 11.	
0.000704	3.35°
.002685	3.05
.01151	2.69
.03120	2.42
.1473	2.13
.4129	1.80
.7501	1.76
1.253	1.86
K_2SO_4, 174.4: 3, 5, 6, 10, 12.	
0.00200	5.4°
.00398	5.3
.00865	4.9
.0200	4.76
.0500	4.60
.1000	4.32
.200	4.07
.454	3.87
$CuSO_4$, 159.7: 1, 4, 11.	
0.000286	3.3°
.000843	3.15
.002279	3.03
.006670	2.79
.01463	2.59
.1051	2.28
.2074	1.95
.4043	1.84
.8898	1.76
$MgSO_4$, 120.4: 1, 4, 11.	
0.000675	3.29
.002381	3.10
.01263	2.72
.0580	2.65
.2104	2.23
0.4978	2.02°
.8112	2.01
1.5233	2.28
$BaCl_2$, 208.3: 3, 6, 13.	
0.00200	5.5°
.00498	5.2
.0100	5.0
.0200	4.95
.04805	4.80
.100	4.69
.200	4.66
.500	4.82
.586	5.03
.750	5.21
$CdCl_2$, 183.3: 3, 14.	
0.00299	5.0°
.00690	4.8
.0200	4.64
.0541	4.11
.0818	3.93
.214	3.39
.429	3.03
.858	2.71
1.072	2.75
$CuCl_2$, 134.5: 9.	
0.0350	4.9°
.1337	4.81
.3380	4.92
.7149	5.32
$CoCl_2$, 129.9: 9.	
0.0276	5.0°
.1094	4.9
.2369	5.03
.4399	5.30
.538	5.5
$CaCl_2$, 111.0: 5, 13–16.	
0.0100	5.1°
.05028	4.85
.1006	4.79
.5077	5.33
.946	5.3
2.432	8.2
3.469	11.5
3.829	14.4
0.0478	5.2
.153	4.91
.331	5.15
.612	5.47
.998	6.34
$MgCl_2$, 95.26: 6, 14.	
0.0100	5.1°
.0500	4.98
.1500	4.96
.3000	5.186
.6099	5.69
KCl, 74.60: 9, 17–19.	
0.02910	3.54°
.05845	3.46
.112	3.43
.3139	3.41
.476	3.37
1.000	3.286
1.989	3.25
3.269	3.25
NaCl, 58.50: 3, 20, 12, 16.	
0.00399	3.7°
.01000	3.67
.0221	3.55
.04949	3.51
.1081	3.48
.2325	3.42
.4293	3.37
.700	3.43
NH_4Cl, 53.52: 6, 15.	
0.0100	3.6°
.0200	3.56
.0350	3.50
.1000	3.43
.2000	3.396
.4000	3.393
.7000	3.41
LiCl, 42.48: 9, 15.	
0.00992	3.7°
.0455	3.5
.09952	3.53
.2474	3.50
.5012	3.61
.7939	3.71
$BaBr_2$, 297.3: 14.	
0.100	5.1°
.150	4.9
.200	5.00
.500	5.18
$AlBr_3$, 267.0: 9.	
0.0078	1.4°
.0559	1.2
.1971	1.07
.4355	1.07

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Compiled from Landolt-Börnstein-Meyerhoffer's Physikalisch-chemische Tabellen.

TABLE 215 (*continued*).

LOWERING OF FREEZING-POINTS BY SALTS IN SOLUTION (*continued*).

$\frac{\text{g. mol.}}{1000 \text{ g. } H_2O}$	Molecular Lowering.
$CdBr_2$, 272.3: 3, 14.	
0.00324	5.1°
.00718	4.6
.03627	3.84
.0719	3.39
.1122	3.18
.220	2.96
.440	2.76
.800	2.59
$CuBr_2$, 223.5: 9.	
0.0242	5.1°
.0817	5.1
.2255	5.27
.6003	5.89
$CaBr_2$, 200.0: 14.	
0.0871	5.1°
.1742	5.18
.3484	5.30
.5226	5.64
$MgBr_2$, 184.28: 14.	
0.0517	5.4°
.103	5.16
.207	5.26
.517	5.85
KBr, 119.1: 9, 21.	
0.0305	3.61°
.1850	3.49
.6801	3.30
.250	3.78
.500	3.30
CdI_2, 366.1: 3, 5, 22.	
0.00210	4.5°
.00626	4.0
.02062	3.52
.04857	2.70
.1360	2.35
.333	2.13
.684	2.23
.888	2.51
KI, 166.0: 9, 2.	
0.0651	3.5°
.2782	3.50
.6030	3.42
1.003	3.37
SrI_2, 341.3: 22.	
0.054	5.1°
.108	5.2
.216	5.35
.327	5.52
NaOH, 40.06: 15.	
0.02002	3.45°
.05005	3.45
.1001	3.41
.2000	3.407

$\frac{\text{g. mol.}}{1000 \text{ g. } H_2O}$	Molecular Lowering.
KOH, 56.16: 1, 15, 23.	
0.00352	3.60°
.00770	3.59
.02002	3.44
.05006	3.43
.1001	3.42
.2003	3.424
.230	3.50
.465	3.57
CH_3OH, 32.03: 24, 25.	
0.0100	1.8°
.0301	1.82
.2018	1.811
1.046	1.86
3.41	1.88
6.200	1.944
C_2H_5OH, 46.04: 1, 12, 17, 24–27.	
0.000402	1.67°
.004993	1.67
.0100	1.81
.02892	1.707
.0705	1.85
.1292	1.829
.2024	1.832
.5252	1.834
1.0891	1.826
1.760	1.83
3.901	1.92
7.91	2.02
11.11	2.12
18.76	1.81
0.0173	1.80
.0778	1.79
K_2CO_3, 138.30: 6.	
0.0100	5.1°
.0200	4.93
.0500	4.71
.100	4.54
.200	4.39
Na_2CO_3, 106.10: 6.	
0.0100	5.1°
.0200	4.93
.0500	4.64
.1000	4.42
.2000	4.17
Na_2SO_3, 126.2: 28.	
0.1044	4.51°
.3397	3.74
.7080	3.38
Na_2HPO_4, 142.1: 22, 29.	
0.01001	5.0°
.02003	4.84
.05008	4.60
.1002	4.34

$\frac{\text{g. mol.}}{1000 \text{ g. } H_2O}$	Molecular Lowering.
Na_2SiO_3, 122.5: 15.	
0.01052	6.4°
.05239	5.86
.1048	5.28
.2099	4.66
.5233	3.99
HCl, 36.46: 1–3, 6, 13, 18, 22.	
0.00305	3.68°
.00695	3.66
.0100	3.6
.01703	3.59
.0500	3.59
.1025	3.56
.2000	3.57
.3000	3.612
.464	3.68
.516	3.79
1.003	3.95
1.032	4.10
1.500	4.42
2.000	4.97
2.115	4.52
3.000	6.03
3.053	4.90
4.065	5.67
4.657	6.19
HNO_3, 63.05: 3, 13, 15.	
0.02004	3.55°
.05015	3.50
.0510	3.71
.1004	3.48
.1059	3.53
.2015	3.45
.250	3.50
.500	3.62
1.000	3.80
2.000	4.17
3.000	4.64
H_3PO_2, 66.0: 29.	
0.1260	2.90°
.2542	2.75
.5171	2.59
1.071	2.45
HPO, 82.0: 4, 5.	
0.0745	3.0°
.1241	2.8
.2482	2.6
1.00	2.39
H_3PO_4, 98.0: 6, 22.	
0.0100	2.8°
.0200	2.68
.0500	2.49
.1000	2.36
.2000	2.25

$\frac{\text{g. mol.}}{1000 \text{ g. } H_2O}$	Molecular Lowering.
0.472	2.20°
.944	2.27
1.620	2.60
$(COOH)_2$, 90.02: 4, 15.	
0.01002	3.3°
.02005	3.19
.05019	3.03
.1006	2.83
.2022	2.64
.366	2.56
.648	2.3
$C_3H_5(OH)_3$, 92.06: 24, 25.	
0.0200	1.86°
.1008	1.86
.2031	1.85
.535	1.91
2.40	1.98
5.24	2.13
$(C_2H_5)_2O$, 74.08: 24.	
0.0100	1.6°
.0201	1.67
.1011	1.72
.2038	1.702
Dextrose, 180.1: 24, 30.	
0.0198	1.84°
.0470	1.85
.1326	1.87
.4076	1.894
1.102	1.921
Levulose, 180.1: 24, 25.	
0.0201	1.87°
.2050	1.871
.554	2.01
1.384	2.32
2.77	3.04
CHO, 342.2: 1, 24, 26.	
0.000332	1.90°
.001410	1.87
.009978	1.86
.0201	1.88
.1305	1.88
H_2SO_4, 98.08: 13, 20, 31–33.	
0.00461	4.8°
.0100	4.49
.0200	4.32
.0461	4.10
.100	3.96
.200	3.85
.400	3.98
1.000	4.19
1.500	4.96
2.000	5.65
2.500	6.53

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TABLE 216.

RISE OF BOILING-POINT PRODUCED BY SALTS DISSOLVED IN WATER.*

This table gives the number of grammes of the salt which, when dissolved in 100 grammes of water, will raise the boiling-point by the amount stated in the headings of the different columns. The pressure is supposed to be 76 centimetres.

Salt.	1° C.	2°	3°	4°	5°	7°	10°	15°	20°	25°
$BaCl_2 + 2H_2O$	15.0	31.1	47.3	63.5	(71.6 gives 4°.5 rise of temp.)					
$CaCl_2$	6.0	11.5	16.5	21.0	25.0	32.0	41.5	55.5	69.0	84.5
$Ca(NO_3)_2 + 2H_2O$	12.0	25.5	39.5	53.5	68.5	101.0	152.5	240.0	331.5	443.5
KOH	4.7	9.3	13.6	17.4	20.5	26.4	34.5	47.0	57.5	67.3
$KC_2H_3O_2$	6.0	12.0	18.0	24.5	31.0	44.0	63.5	98.0	134.0	171.5
KCl	9.2	16.7	23.4	29.9	36.2	48.4	(57.4 gives a rise of 8°.5)			
K_2CO_3	11.5	22.5	32.0	40.0	47.5	60.5	78.5	103.5	127.5	152.5
$KClO_3$	13.2	27.8	44.6	62.2						
KI	15.0	30.0	45.0	60.0	74.0	99.5	134.	185.0	(220 gives 18°.5)	
KNO_3	15.2	31.0	47.5	64.5	82.0	120.5	188.5	338.5		
$K_2C_4H_4O_6 + \frac{1}{2}H_2O$	18.0	36.0	54.0	72.0	90.0	126.5	182.0	284.0		
$KNaC_4H_4O_6$	17.3	34.5	51.3	68.1	84.8	119.0	171.0	272.5	390.0	510.0
$KNaC_4H_4O_6 + 4H_2O$	25.0	53.5	84.0	118.0	157.0	266.0	554.0	5510.0		
$LiCl$	3.5	7.0	10.0	12.5	15.0	20.0	26.0	35.0	42.5	50.0
$LiCl + 2H_2O$	6.5	13.0	19.5	26.0	32.0	44.0	62.0	92.0	123.0	160.5
$MgCl_2 + 6H_2O$	11.0	22.0	33.0	44.0	55.0	77.0	110.0	170.0	241.0	334.5
$MgSO_4 + 7H_2O$	41.5	87.5	138.0	196.0	262.0					
$NaOH$	4.3	8.0	11.3	14.3	17.0	22.4	30.0	41.0	51.0	60.1
$NaCl$	6.6	12.4	17.2	21.5	25.5	33.5	(40.7 gives 8°.8 rise)			
$NaNO_3$	9.0	18.5	28.0	38.0	48.0	68.0	99.5	156.0	222.0	
$NaC_2H_3O_2 + 3H_2O$	14.9	30.0	46.1	62.5	79.7	118.1	194.0	480.0	6250.0	
$Na_2S_2O_3$	14.0	27.0	39.0	49.5	59.0	77.0	104.0	152.0	214.5	311.0
Na_2HPO_4	17.2	34.4	51.4	68.4	85.3					
$Na_2C_4H_4O_6 + 2H_2O$	21.4	44.4	68.2	93.9	121.3	183.0	(237.3 gives 8°.4 rise)			
$Na_2S_2O_3 + 5H_2O$	23.8	50.0	78.6	108.1	139.3	216.0	400.0	1765.0		
$Na_2CO_3 + 10H_2O$	34.1	86.7	177.6	369.4	1052.9					
$Na_2B_4O_7 + 10H_2O$	39.	93.2	254.2	898.5	(5555.5 gives 4°.5 rise)					
NH_4Cl	6.5	12.8	19.0	24.7	29.7	39.6	56.2	88.5		
NH_4NO_3	10.0	20.0	30.0	41.0	52.0	74.0	108.0	172.0	248.0	337.0
NH_4SO_4	15.4	30.1	44.2	58.0	71.8	99.1	(115.3 gives 108.2)			
$SrCl_2 + 6H_2O$	20.0	40.0	60.0	81.0	103.0	150.0	234.0	524.0		
$Sr(NO_3)_2$	24.0	45.0	63.6	81.4	97.6					
$C_4H_6O_6$	17.0	34.4	52.0	70.0	87.0	123.0	177.0	272.0	374.0	484.0
$C_2H_2O_4 + 2H_2O$	19.0	40.0	62.0	86.0	112.0	169.0	262.0	540.0	1316.0	50000.0
$C_6H_6O_7 + H_2O$	29.0	58.0	87.0	116.0	145.0	208.0	320.0	553.0	952.0	

Salt.	40°	60°	60°	100°	120°	140°	160°	180°	200°	240°
$CaCl_2$	137.5	222.0	314.0							
KOH	92.5	121.7	152.6	185.0	219.8	263.1	312.5	375.0	444.4	623.0
$NaOH$	93.5	150.8	230.0	345.0	526.3	800.0	1333.0	2353.0	6452.0	–
NH_4NO_3	682.0	1370.0	2400.0	4099.0	8547.0	∞				
$C_4H_6O_6$	980.0	3774.0	(infinity gives 170)							

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* Compiled from a paper by Gerlach, "Zeit. f. Anal. Chem." vol. 26.

TABLE 217.

FREEZING MIXTURES.[*]

Column 1 gives the name of the principal refrigerating substance, *A* the proportion of that substance, *B* the proportion of a second substance named in the column, *C* the proportion of a third substance, *D* the temperature of the substances before mixture, *E* the temperature of the mixture, *F* the lowering of temperature, *G* the temperature when all snow is melted, when snow is used, and *H* the amount of heat absorbed in heat units (small calories when *A* is grammes). Temperatures are in Centigrade degrees.

Substance.	*A*	*B*	*C*	*D*	*E*	*F*	*G*	*H*
$NaC_2H_3O_2$ (cryst.)	85	H_2O–100	–	10.7	— 4.7	15.4	–	–
NH_4Cl . . .	30	" "	–	13.3	— 5.1	18.4	–	–
$NaNO_3$ . . .	75	" "	–	13.2	— 5.3	18.5	–	–
$Na_2S_2O_3$ (cryst.) .	110	" "	–	10.7	— 8.0	18.7	–	–
KI	140	" "	–	10.8	— 11.7	22.5	–	–
$CaCl_2$ (cryst.) .	250	" "	–	10.8	— 12.4	23.2	–	–
NH_4NO_3 . .	60	" "	–	13.6	— 13.6	27.2	–	–
$(NH_4)_2SO_4$ . .	25	" 50	NH_4NO_3–25	–	–	26.0	–	–
NH_4Cl . . .	25	" "	" "	–	–	22.0	–	–
$CaCl_2$ . . .	25	" "	" "	–	–	20.0	–	–
KNO_3 . . .	25	" "	NH_4Cl–25	–	–	20.0	–	–
Na_2SO_4 . .	25	" "	" "	–	–	19.0	–	–
$NaNO_3$ . . .	25	" "	" "	–	–	17.0	–	–
K_2SO_4 . . .	10	Snow 100	–	— 1	— 1.9	0.9	–	
Na_2CO_3 (cryst.) .	20	" "	–	— 1	— 2.0	1.0	–	–
KNO_3 . . .	13	" "	–	— 1	— 2.85	1.85	–	–
$CaCl_2$ . . .	30	" "	–	— 1	— 10.9	9.9	–	–
NH_4Cl . . .	25	" "	–	— 1	— 15.4	14.4	–	–
NH_4NO_3	45	" "	–	— 1	— 16.75	15.75	–	–
$NaNO_3$ . . .	50	" "	–	— 1	— 17.75	16.75	–	–
NaCl . . .	33	" "	–	— 1	— 21.3	20.3	–	–
$H_2SO_4 + H_2O$ (66.1 % H_2SO_4)	1	" 1.097	–	— 1	— 37.0	36.0	— 37.0	0.0
	1	" 1.26	–	— 1	— 36.0	35.0	— 30.2	17.0
	1	" 1.38	–	— 1	— 35.0	34.0	— 25.0	27.0
	1	" 2.52	–	— 1	— 30.0	29.0	— 12.4	133.0
	1	" 4.32	–	— 1	— 25.0	24.0	— 7.0	273.0
	1	" 7.92	–	— 1	— 20.0	19.0	— 3.1	553.0
	1	" 13.08	–	— 1	— 16.0	15.0	— 2.1	967.0
$CaCl_2 + 6H_2O$	1	" 0.35	–	0	–	–	0.0	52.1
	1	" .49	–	0	–	–	— 19.7	49.5
	1	" .61	–	0	–	–	— 39.0	40.3
	1	" .70	–	0	–	–	— 54.9[†]	30.0
	1	" .81	–	0	–	–	— 40.3	46.8
	1	" 1.23	–	0	–	–	— 21.5	88.5
	1	" 2.46	–	0	–	–	— 9.0	192.3
	1	" 4.92	–	0	–	–	— 4.0	392.3
Alcohol at 4°	77	" 73	–	0	— 30.0	–	–	–
	–	CO_2 solid	–	–	— 72.0	–	–	–
Chloroform . .	–	" "	–	–	— 77.0	–	–	–
Ether . . .	–	" "	–	–	— 77.0	–	–	–
Liquid SO_2 . .	–	" "	–	–	— 82.0	–	–	–
NH_4NO_3 .	1	H_2O–.75	–	20	5.0	–	–	33.0
	1	" .94	–	20	— 4.0	–	–	21.0
	1	" "	–	10	— 4.0	–	–	34.0
	1	" "	–	5	— 4.0	–	–	40.5
	1	Snow "	–	0	— 4.0	–	–	122.2
	1	H_2O–1.20	–	10	— 14.0	–	–	17.9
	1	Snow "	–	0	— 14.0	–	–	129.5
	1	H_2O–1.31	–	10	— 17.5[†]	–	–	10.6
	1	Snow "	–	0	— 17.5[†]	–	–	131.9
	1	H_2O–3.61	–	10	— 8.0	–	–	0.4
	1	Snow "	–	0	— 8.0	–	–	327.0

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[*] Compiled from the results of Cailletet and Colardeau, Hammerl, Hanamann, Moritz, Pfanndler, Rudorf, and Tollinger.

[†] Lowest temperature obtained.

TABLE 218.

CRITICAL TEMPERATURES, PRESSURES, VOLUMES, AND DENSITIES OF GASES.*

θ = Critical temperature.
P = Pressure in atmospheres.
ϕ = Volume referred to air at 0° and 76 centimetres pressure.
d = Density in grammes per cubic centimetre.

Substance.	θ	P	ϕ	d	Observer.
Air	−140.0	39.0		–	Olszewski.
Alcohol (C_2H_6O)	243.6	62.76	0.00713	0.288	Ramsay-Young.
" "	237.9	–		–	Mean of ten.
" (CH_4O)	239.95	78.5	–	–	Young.
Ammonia	130.0	115.0	–	–	Dewar.
Argon	−121.0	50.6	–	1.5	Olszewski.
Benzol	288.5	47.9	0.00981	0.305	Young.
Bromine	302.2	–	0.00605	1.18	Nadejdine.
Carbon dioxide	30.92	77	0.0066	–	Andrews.
" monoxide	−141.1	35.9	–	–	Wroblewski.
" disulphide	277.7	78.1	–	–	Hannay.
Chloroform	260.0	54.9	–	–	Sajotschewsky.
Chlorine	141.0	83.9	–	–	Dewar.
"	146.0	–	–	–	Knietsch.
Ether	197.0	35.77	0.01584	0.208	Battelli.
"	194.4	35.61	0.01344	0.262	Young.
Ethane	35.0	45.2	–	–	Dewar.
Ethylene	9.2	58.0	–	–	Van der Waals.
"	13.0	–	0.00569	0.21	Cailletet.
Helium	<−264.0	–	–	–	Dewar.
Hydrogen	−234.5	20.0	–	–	Dewar.
" chloride	51.25	86.0	–	–	Ansdell.
" "	52.3	86.0	–	0.61	Dewar.
" sulphide	100.0	88.7	–	–	Olszewski.
Krypton	−62.5	54.3	–	–	Ramsey-Travers.
Methane	−81.8	54.9	–	–	Olszewski.
"	−99.5	50.0	–	–	Dewar.
Neon	<−205.0	–	–	–	Ramsey-Travers.
Nitric oxide (NO)	−93.5	71.2	–	–	Olszewski.
Nitrogen	−146.0	35.0	–	0.44	"
" monoxide (N_2O)	35.4	75.0	0.0048	0.41	Dewar, Cailletet.
Oxygen	−118.0	50.0	–	0.6044	Wroblewski.
Sulphur dioxide	155.4	78.9	0.00587	0.49	Sajotschewsky, Cailletet.
Water	358.1	–	0.001874	0.429	Nadejdine.
"	364.3	194.6	0.00386	–	Batelli.

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* Abridged for the most part from Landolt and Börnstein's "Phys. Chem. Tab."

TABLE 219.

COEFFICIENTS OF THERMAL EXPANSION.

Coefficients of Linear Expansion of the Chemical Elements.

In the heading of the columns *T* is the temperature or range of temperature; *C* is the coefficient of linear expansion; A_1 is the authority for *C*; *M* is the mean coefficient of expansion between 0° and 100° C.; α and β are the coefficients in the equation $l_t = l_0 (1 + \alpha t + \beta t^2)$, where l_0 is the length at 0° C. and l_t the length at t° C.; A_2 is the authority for α, β, and *m*.

Substance.	T	$C \times 10^4$	A_1	$M \times 10^4$	$\alpha \times 10^4$	$\beta \times 10^6$	A_2
Aluminum	40	0.2313	1	0.2220	-	-	2
"	600	.3150	3				
"	−191 to +16	.1835	4	-	.23536	.00707	5
Antimony:							
Parallel to cryst. axis	40	.1692	1				
Perp. to axis	40	.0882	1				
Mean	40	.1152	1	.1056	.0923	.0132	6
Arsenic	40	.0559	1				
Bismuth:							
Parallel to axis	40	.1621	1				
Perp. to axis	40	.1208	1				
Mean	40	.1346	1	.1316	.1167	.0149	6
Cadmium	40	.3069	1	.3159	.2693	.0466	6
Carbon:							
Diamond	40	.0118	1				
Gas carbon	40	.0540	1				
Graphite	40	.0786	1				
Anthracite	40	.2078	1				
Cobalt	40	.1236	1				
Copper	40	.1678	1	.1666	.1481	.0185	6
"	−191 to +16	.1409	4	–	.16070	.00403	5
Gold	40	.1443	1	.1470	.1358	.0112	6
Indium	40	.4170	1				
Iron:							
Soft	40	.1210	1				
Cast	40	.1061	1				
"	−191 to +16	.0850	4				
Wrought	−18 to 100	.1140	7		.11705	.005254	8
Steel	40	.1322	1	–	.09173	.008336	8
" annealed	40	.1095	1	.1089	.1038	.0052	9
Lead	40	.2924	1	.2709	.0273	.0074	6
Magnesium	40	.2694	1				
Nickel	40	.1279	1	–	.13460	.003315	8
"	−191 to +16	.1012	4				
Osmium	40	.0657	1				
Palladium	40	.1176	1	–	.11670	.002187	8
Phosphorus	0–40	1.2530	10				
Platinum	40	0.0899	1	–	.08868	.001324	8
Potassium	0–50	.8300	11				
Rhodium	40	.0850	1				
Ruthenium	40	.0960	1				
Selenium	40	.3680	1	.6604	–	–	12
Silicon	40	.0763	1				
Silver	40	.1921	1	–	.18270	.004793	8
"	−191 to +16	.1704	4				
Sulphur:							
Cryst. mean	40	.6413	1	1.180	–	–	12
Tellurium	40	.1675	1	.3687	–	–	12
Thallium	40	.3021	1				
Tin	40	.2234	1	.2296	.2033	.0263	6
Zinc	40	.2918	1	.2976	.2741	.0234	6

1 Fizeau.
2 Calvert, Johnson and Lowe.
3 Chatelier.
4 Henning.
5 Dittenberger.
6 Matthiessen.
7 Andrews.
8 Holborn-Day.
9 Benoit.
10 Pisati and De Franchis.
11 Hagen.
12 Spring.

The above table has been partly compiled from the results published by Fizeau, "Comptes Rendus," vol. 68, and Matthiessen, "Proc. Roy. Soc.," vol. 15.
The Holborn-Day data are for temperatures from 20° to 1000° C. The Dittenberger, 0° to 600° C.

TABLE 220.

COEFFICIENTS OF THERMAL EXPANSION.

Coefficients of Linear Expansion for Miscellaneous Substances.

The coefficient of cubical expansion may be taken as three times the linear coefficient. *T* is the temperature or range of temperature, *C* the coefficient of expansion, and *A* the authority.

Substance.	$T°$ C.	$C \times 10^4$	*A*.
Brass:			
Cast . . .	0–100	0.1875	1
Wire . . .	"	0.1930	1
— . . .	"	.1783–.193	2
71.5Cu+27.7Zn+0.3Sn+0.5Pb	40	0.1859	3
71Cu+29Zn .	0–100	0.1906	4
Bronze:			
3Cu+1Sn . .	16.6–100	0.1844	5
" " . .	16.6–350	0.2116	5
" " . .	16.6–957	0.1737	5
86.3Cu+9.7Sn+4Zn	40	0.1782	3
97.6Cu+2.2Sn+0.2P hard	0–80	0.1713	6
97.6Cu+2.2Sn+0.2P soft	"	0.1708	6
Caoutchouc . .	–	.657–.686	2
" . . .	16.7–25.3	0.770	7
Constantine . .	4–29	0.4570	–
Ebonite . . .	25.3–35.4	0.842	7
Fluor spar: CaF_2 .	0–100	0.1950	8
German silver .	"	0.1836	8
Gold-platinum: 2Au+1Pt	"	0.1523	4
Gold-copper: 2Au+1Cu	"	0.1552	4
Glass:			
Tube . . .	"	0.0833	1
" . . .	"	0.0828	9
Plate . . .	"	0.0891	10
Crown (mean) .	"	0.0897	10
" . . .	50–60	0.0954	11
Flint . . .	"	0.0788	11
Jena thermometer 16^{III} normal	0–100	0.081	12
" 59^{III} .	"	0.058	12
" " .	—191 to +16	0.424	13
Gutta percha . .	20	1.983	14
Ice	—20 to —1	0.51	15
Iceland spar:			
Parallel to axis .	0–80	0.2631	6
Perpendicular to axis	"	0.0544	6
Lead-tin (solder) 2Pb+1Sn	0–100	0.2508	1
Magnalium . .	12–39	0.238	16
Marble . . .	15–100	0.117	17
Paraffin . . .	0–16	1.0662	18
" . . .	16–38	1.3030	18
" . . .	38–49	4.7707	18
Platinum-iridium 10Pt+1Ir	40	0.0884	3

Substance.	$T°$ C.	$C \times 10^4$	*A*.
Platinum-silver: 1Pt+2Ag	0–100	0.1523	4
Porcelain . .	20–790	0.0413	19
" Bayeux .	1000–1400	0.0553	20
Quartz:			
Parallel to axis .	0–80	0.0797	6
" " " .	—190 to +16	0.1070	21
Perpend." " .	0–80	0.1337	6
Quartz glass . .	—190 to +16	—.0026	13
Rock salt . .	40	0.4040	3
Speculum metal .	0–100	0.1933	1
Topaz:			
Parallel to lesser horizontal axis	"	0.0832	8
Parallel to greater horizontal axis	"	0.0836	8
Parallel to vertical axis	"	0.0472	8
Tourmaline:			
Parallel to longitudinal axis	"	0.0937	8
Parallel to horizontal axis	"	0.0773	8
Type metal . .	16.6–254	0.1952	5
Vulcanite . .	0–18	0.6360	22
Wedgwood ware .	0–100	0.0890	5
Wood:			
Parallel to fibre:			
Ash . . .	"	0.0951	23
Beech . .	2–34	0.0257	24
Chestnut . .	"	0.0649	24
Elm . . .	"	0.0565	24
Mahogany .	"	0.0361	24
Maple . .	"	0.0638	24
Oak . . .	"	0.0492	24
Pine . . .	"	0.0541	24
Walnut . .	"	0.0658	24
Across the fibre:			
Beech . .	"	0.614	24
Chestnut . .	"	0.325	24
Elm . . .	"	0.443	24
Mahogany .	"	0.404	24
Maple . .	"	0.484	24
Oak . . .	"	0.544	24
Pine . . .	"	0.341	24
Walnut . .	"	0.484	24
Wax: White . .	10–26	2.300	25
" . .	26–31	3.120	25
" . .	31–43	4.860	25
" . .	43–57	15.227	25

1 Smeaton.
2 Various.
3 Fizeau.
4 Matthiessen.
5 Daniell.
6 Benoit.
7 Kohlrausch.
8 Pfaff.
9 Deluc.
10 Lavoisier and Laplace.
11 Pulfrich.
12 Schott.
13 Henning.
14 Russner.
15 Mean.
16 Stadthagen.
17 Fröhlich.
18 Rodwell.
19 Braun.
20 Deville and Troost.
21 Scheel.
22 Mayer.
23 Glatzel.
24 Villari.
25 Kopp.

TABLE 221.

COEFFICIENTS OF THERMAL EXPANSION.

Coefficients of Cubical Expansion of some Crystalline and other Solids.*

T = temperature or range of temperature, C = coefficient of cubical expansion, A = authority.

Substance.	T	$C \times 10^4$	A
Antimony	0–100	0.3167	Matthieson.
Beryl	0–100	0.0105	Pfaff.
Bismuth	–	0.4000	Kopp.
Diamond	40	0.0354	Fizeau.
Emerald	40	0.0168	"
Fluor spar	14–47	0.6235	Kopp.
Garnet	0–100	0.2543	Pfaff.
Glass, white tube . .	0–100	0.2648	Regnault.
" green tube . .	0–100	0.2299	"
" Swedish tube . .	0–100	0.2363	"
" hard French tube .	0–100	0.2142	"
" crystal tube . .	0–100	0.2101	"
" common tube . .	0–1	0.2579	"
" Jena	0–100	0.2533	Reichsanstalt.
Ice	—20 to —1	1.1250	Brunner.
Iceland spar . . .	50–60	0.1447	Pulfrich.
Idocrase	0–100	0.2700	Pfaff.
Iron	0–100	0.3550	Dulong and Petit.
"	0–300	0.4410	" " "
Magnetite, Fe_3O_4 . .	0–100	0.2862	Pfaff.
Manganic oxide, Mn_2O_3 .	0–100	0.522	Playfair and Joule.
Orthoclase (adularia) .	0–100	0.1794	Pfaff.
Porcelain	0–100	0.1080	Deville and Troost.
Quartz	50–60	0.3530	Pulfrich.
Rock salt	50–60	1.2120	"
Spinel ruby	40	0.1787	Fizeau.
Sulphur, rhombic . .	0–100	2.2373	Kopp.
Topaz	0–100	0.2137	Pfaff.
Tourmaline	0–100	0.2181	"
Zincite, ZnO	40	0.0279	Fizeau.
Zircon	0–100	0.2835	Pfaff.

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* For more complete tables of cubical expansion, see Clarke's "Constants of Nature," (Smithsonian Collections), published in 1876.

TABLE 222.

COEFFICIENTS OF THERMAL EXPANSION.

Coefficients of Cubical Expansion of Liquids.

This table contains the coefficients of expansion of some liquids and solutions of salts. When not otherwise stated atmospheric pressure is to be understood. *T* gives the temperature range, *C* the mean coefficient of expansion for range *T* in degrees C., and A_1 the authority for *C*. α, β, and γ are the coefficients in the volume equation $v_t = v_0 (1 + \alpha t + \beta t^2 + \gamma t^3)$, and *m* the mean coefficient for range 0°–100° C., and A_2 is the authority for these.

Liquid.	*T*	*C* × 1000	A_1	*m* × 100	$\alpha \times 1000$	$\beta \times 10^6$	$\gamma \times 10^8$	A_2
Acetic acid	16°–107°	–	–	.1433	1.0630	0.1264	1.0876	3
Acetone	0–54	–	–	.1616	1.3240	3.8090	0.8798	3
Alcohol:								
Amyl	—15 to +80	–	–	–	0.8900	0.6573	1.1846	4
Ethyl, sp. gr. .8095 .	0–80	–	–	–	1.0414	0.7836	1.7168	5
" 50 % by volume	0–39	–	–	–	0.7450	1.850	0.730	6
" 30 % "	18–39	–	–	–	0.2928	17.900	11.87	6
" 500 atmo. press.	0–40	.866	1		–	–	–	–
" 3000 " "	0–40	.524	1	–	–	–	–	–
Methyl	—38 to +70	–	–	.1433	1.1856	1.5649	0.9111	4
Benzene	11–81	–	–	.1385	1.1763	1.2775	0.8065	5
Bromine	—7 to +60	–	–	.1168	1.0382	1.7114	0.5447	4
Calcium chloride:								
$CaCl_2$, 5.8 % solution	18–25	–	–	.0506	0.0788	4.2742	–	7
$CaCl_2$, 40.9 % " .	17–24	–	–	.0510	0.4238	0.8571	–	7
Carbon disulphide . .	—34 to +60	–	–	.1468	1.1398	1.3706	1.9122	4
500 atmos. pressure .	0–50	.940	1	–	–	–	–	–
3000 " " .	0–50	.581	1	–	–	–	–	–
Chloroform	0–63	–	–	.1399	1.1071	4.6647	1.7433	4
Ether	—15 to +38		–	.2150	1.5132	2.3592	4.0051	4
Glycerine	–	–	–	.0534	0.4853	0.4895	–	8
Hydrochloric acid:								
$HCl + 6.25H_2O$ . .	0–30	–	–	.0489	0.4460	0.430	–	9
$HCl + 50H_2O$ . .	0–30	–	–	.0933	0.0625	8.710	–	9
Mercury	24–299	–	–	–	0.18182	0.00078	–	15
Olive oil	–	–	–	.0742	0.6821	1.1405	—.539	11
Potassium chloride:								
KCl, 2.5 % solution .	–	–	–	.0572	–	–	–	7
KCl, 24.3 % "	–	–	–	.0477	–	–	–	7
Potassium nitrate:								
KNO_3, 5.3 % sol'n	–	–	–	.0539	–	–	–	12
KNO_3, 21.9 % "	–	–	–	.0577	–	–	–	12
Phenol, C_6H_6O . . .	36–157	–	–	.0899	0.8340	0.1073	0.4446	13
Petroleum	7–38	.992	2	–	–	–	–	–
Sp. gr. 0.8467 . . .	24–120	–	–	.1039	0.8994	1.396	–	14
Sodium chloride:								
NaCl, 1.6 % solution .	–	–	–	.1067	0.0213	10.462	–	9
Sodium sulphate:								
Na_2SO_4, 24 % sol'n .	10–40	–	–	.0611	0.3599	2.516	–	9
Sodium nitrate:								
$NaNO_3$, 36.2 % sol'n .	20–78	–	–	.0627	0.5408	1.075	–	12
Sulphuric acid:								
H_2SO_4	0–30	–	–	.0489	0.5758	0.864	–	9
$H_2SO_4 + 50H_2O$.	0–30	–	–	.0799	0.2835	5.160	–	9
Turpentine	—9 to +106	–	–	.1051	0.9003	1.959	–	5
Water	0–33	–	–	–	—.0643	8.505	6.790	15

AUTHORITIES.

1 Amagat.
2 Barrett.
3 Zander.
4 Pierre.
5 Kopp.
6 Recknagel.
7 Decker.
8 Emo.
9 Marignac.
10 Broch.
11 Spring.
12 Nicol.
13 Pinette.
14 Frankenheim.
15 Scheel.

TABLE 223.

COEFFICIENTS OF THERMAL EXPANSION.

Coefficients of Expansion of Gases.

Pressures are given in centimetres of mercury.

Coefficient at Constant Volume.

Substance.	Pressure cm.	Coefficient × 100.	Reference.
Air . . .	.6	.37666	1
" . . .	1.3	.37172	"
" . . .	10.0	.36630	"
" . . .	25.4	.36580	"
" . . .	75.2	.36660	"
" 0°–100° . .	100.1	.36744	2
" . . .	76.0	.36650	3
" . . .	200.0	.36903	"
" . . .	2000.	.38866	"
" . . .	10000.	.4100	"
Argon . . .	51.7	.3668	4
Carbon dioxide .	76.0	.36856	3
" " . .	1.8	.36753	1
" " . .	5.6	.36641	"
" " . .	74.9	.37264	"
" " 0°–20°	51.8	.36985	2
" " 0°–40°	51.8	.36972	"
" " 0°–100°	51.8	.36981	"
" " 0°–20°	99.8	.37335	"
" " 0°–100°	99.8	.37262	"
" " 0°–100°	100.0	.37248	5
Carbon monoxide .	76.	.36667	3
Helium . . .	56.7	.3665	4
Hydrogen 16°–132°	.0077	.3328	6
" 15°–132°	.025	.3623	"
" 12°–185°	.47	.3656	"
" . . .	.93	.37002	1
" . . .	11.2	.36548	"
" . . .	76.4	.36504	"
" 0°–100°	100.0	.36626	2
Nitrogen 13°–132°	.06	.3021	6
" 9°–133°	.53	.3290	"
" 0°–20°	100.2	.36754	2
" 0°–100°	100.2	.36744	"
" . . .	76.	.36682	7
Oxygen 11°–132° .	.007	.4161	6
" 9°–132° .	.25	.3984	"
" 11°–132° .	.51	.3831	"
" . . .	1.9	.36683	8
" . . .	18.5	.36690	"
" . . .	75.9	.36681	"
Nitrous oxide .	76.	.3676	3
Sulph'r dioxide SO_2	76.	.3845	"

Coefficient at Constant Pressure.

Substance.	Pressure cm.	Coefficient × 100.	Reference.
Air . . .	76.	.3671	3
" . . .	257.	.3693	"
" 0°–100° . .	100.1	.36728	2
Hydrogen 0°–100°	100.0	.36600	"
" . . .	200 Atm.	.332	9
" . . .	400 "	.295	"
" . . .	600 "	.261	"
" . . .	800 "	.242	"
Carbon dioxide .	76.	.3710	3
" " 0°–20°	51.8	.37128	2
" " 0°–40°	51.8	.37100	"
" " 0°–100°	51.8	.37073	"
" " 0°–20°	99.8	.37602	"
" " 0°–100°	99.8	.37410	"
" " 0°–20°	137.7	.37972	"
" " 0°–100°	137.7	.37703	"
" " 0°–7.5°	2621.	.1097	6
" " 64°–100°	2621.	.6574	"
Carbon monoxide .	76.	.3669	3
Nitrous oxide .	76.	.3719	"
Sulphur dioxide .	76.	.3903	"
" " .	98.	.3980	"
Water-vapor 0°–119°	76.	.4187	10
0°–141°	76.	.4189	"
0°–162°	76.	.4071	"
0°–200°	76.	.3938	"
0°–247°	76.	.3799	"

Thomson has given, Encyc. Brit. "Heat," the following for the calculation of the expansion, E, between 0° and 100° C. Expansion is to be taken as the change of volume under constant pressure:

Hydrogen, $E = .3662(1 - .00049 V/v)$,
Air, $E = .3662(1 - .0026 V/v)$,
Oxygen, $E = .3662(1 - .0032 V/v)$,
Nitrogen, $E = .3662(1 - .0031 V/v)$,
CO_2 $E = .3662(1 - .0164 V/v)$.

V/v is the ratio of the actual density of the gas at 0° C to what it would have at 0° C and 1 Atm. pressure.

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MECHANICAL EQUIVALENT OF HEAT.

TABLE 224. — Summary.

Taken from J. S. Ames, L'équivalent mécanique de la chaleur, Rapports présentés au congrès international du physique, Paris, 1900.

Name.	Method.	Scale.	Result.	Temp. °C.
Joule . . .	Mechanical .	. . . .	4.173	16.5
Rowland . .	Mechanical .	. . . .	4.195	10.
			4.187	15.
			4.181	20.
			4.176	25.
Reynolds-Morby .	Mechanical .	. . . .	4.1832	Mean-calory.
Griffiths . .	Electrical .	Latimer-Clark = 1.4342v at 15° C.	4.198	15.
			4.192	20.
	$\frac{E^2t}{R}$ . .	International Ohm . . .	4.187	25.
Schuster-Gannon	Electrical Eit.	Latimer-Clark = 1.4340v. at 15° C., Elec. Chem. Equiv. Silver = 0.001118g	4.1905	19.1
Callendar-Barnes	Electrical Eit.	Latimer-Clark = 1.4342v. at 15° C.	4.179	40.

TABLE 225. — Reduced to Gramme-calory at 20° C. (Nitrogen thermometer).

Joule . . .	4.169×10^7 ergs	* 4.169×10^7 ergs.
Rowland . .	4.181 " "	4.181 " "
Griffiths . .	4.192 " "	4.184 " "
Schuster-Gannon .	4.189 " "	4.181 " "
Callendar-Barnes .	4.186 " "	4.178 " "

* Admitting an error of 1 part per 1000 in the electrical scale.

The mean of the last four then gives

1 small (20° C.) calory = 4.181×10^7 ergs.

TABLE 226. — Conversion Factors for Units of Work.

	Joules Watts per sec. Volt-amp. per sec.	Small 20° Calories.	Ergs.	Kilo-gramme-metres.	Foot-poundals.	Foot-pouods.
1 joule = 1 watt per second	1	0.2392	10^7	$\frac{1}{g}$	23.73	$\frac{23.73}{g}$
1 small 20° calory =	4.181	1	4.181×10^7	$\frac{4.181}{g}$	99.22	$\frac{99.22}{g}$
1 erg =	10^{-7}	0.2392×10^{-7}	1	$\frac{10^{-7}}{g}$	23.73×10^{-7}	$\frac{23.73}{g} \times 10^{-7}$
1 kilog.-metre =	g	0.2392g	$g \times 10^7$	1	23.73g	23.73
1 foot-poundal =	.04214	.01008	421400.	$\frac{.04214}{g}$	1	$\frac{1}{g}$
1 foot-pound =	.04214g	.01008g	421400g	.04214	g	1

Table 227.

SPECIFIC HEAT OF THE CHEMICAL ELEMENTS.

Element.	Range * of Temperature, ° C.	Specific heat.	Reference.	Element.	Range * of Temperature, ° C.	Specific heat.	Reference.
Aluminum	—250	0.1428	1	Iodine	9–98	0.0541	25
“	0	.2089	“	Iridium	—186–+18	.0282	26
“	100	.2226	“	“	18–100	.0323	“
“	250	.2382	“	Iron, cast †	20–100	.1189	27
“	500	.2739	“	“ wrought	15–100	.1152	28
“	16–100	.2122	43	“ “	1000–1200	.1989	“
Antimony	15	.0489	2	“ “	500	.176	“
“	100	.0503	“	“ hard-drawn	0–18	.0986	29
“	200	.0520	“	“ “ “	20–100	.1146	“
Arsenic, gray	0–100	.0822	3	“	—185–+20	.0958	4
“ black	0–100	.0861	“	Lanthanum	0–100	.0448	15
Barium	—185–+20	.068	4	Lead	15	.0299	2
Bismuth	—186	.0284	5	“	100	.0311	“
“	0	.0301	6	“	300	.0338	“
“	75	.0309	“	“ fluid	to 310	.0356	30
“	20–100	.0302	7	“ “	“ 360	.0410	“
“ fluid	280–380	.0363	8	“	18–100	.03096	43
Boron	0–100	.307	9	“	16–256	.03191	“
Bromine, solid	—78–—20	.0843	10	Lithium	—100	.5997	31
“ fluid	13–45	.107	11	“	0	.7951	“
Cadmium	21	.0551	2	“	50	.9063	“
“	100	.0570	“	“	100	1.0407	“
“	200	.0594	“	“	190	1.3745	“
“	300	.0617	“	Magnesium	—185–+20	0.222	4
Cæsium	0–26	.0482	12	“	60	.2492	7
Calcium	—185–+20	.157	4	“	325	.3235	“
“	0–181	.170	13	“	625	.4352	“
Carbon, graphite	—50	.114	14	“	20–100	.2492	“
“ “	+11	.160	“	Manganese	60	.1211	“
“ “	977	.467	“	“	325	.1783	“
“ diamond	—50	.0635	“	“	20–100	.1211	“
“ “	+11	.113	“	“	—100	.0979	31
“ “	985	.459	“	“	0	.1072	“
Cerium	0–100	.0448	15	“	100	.1143	“
Chlorine, liquid	0–24	.2262	16	Mercury	—185–+20	.032	4
Chromium	—200	.0666	17	“	0	.03346	32
“	0	.1039	“	“	85	.0328	“
“	100	.1121	“	“	100	.03284	2
“	600	.1872	“	“	250	.03212	“
“	—185–+20	.086	4	Molybdenum	—185–+20	.062	4
Cobalt	500	.1452	18	“	60	.0647	7
“	1000	.204	“	“	475	.0750	“
“	—182–+15	.0822	19	“	20–100	.0647	“
“	15–100	.1030	“	Nickel	—185–+20	.092	4
Copper	17	.0924	2	“	100	.1128	18
“	100	.0942	“	“	300	.1403	“
“	15–238	.09510	43	“	500	.1299	“
“	900	.1259	20	“	1000	.1608	“
“	—181–+13	.0868	21	“	18–100	.109	26
“	23–100	.0940	“	Osmium	19–98	.0311	10
Gallium, liquid	to 113	.080	22	Palladium	—186–+18	.0528	26
“ solid	12–23	.079	22	“	0–100	.0592	24
Germanium	0–100	.0737	23	“	0–1265	.0714	“
Gold	—185–+20	.033	4	Phosphorus, red	0–51	.1829	33
“	0–100	.0316	24	“ yellow	13–36	.202	“
Indium	0–100	.0570	13	“ “	—186–+20	.178	4

See opposite page for References.

* Where one temperature alone is given, the “true” specific heat is given; otherwise, the “mean” specific beat.

† See Appendix. Tables 334–335.

SPECIFIC HEAT.

TABLE 227.—Specific Heat of the Chemical Elements (*continued*).

Element.	Range * of Temperature, °C.	Specific Heat.	Reference.
Platinum .	−186–+18	0.0293	26
" . .	0–100	.0323	24
" . .	100	.0275	34
" . .	500	.0356	35
" . .	700	.0368	"
" . .	900	.0380	"
" . .	1100	.0390	"
" . .	1500	.0407	"
" . .	500	.0335	"
" . .	1100	.0358	"
" . .	1500	.0368	"
Potassium .	−185–+20	.170	4
Rhodium .	10–97	.0580	25
Ruthenium	0–100	.0611	13
Selenium .	−188–+18	.068	36
Silicon . .	−185–+20	.123	4
" . . .	−39.8	.1360	14
" . . .	+57.1	.1833	"
" . . .	232	.2029	"
Silver . .	−186–−79	.0496	26
" . . .	−79–+18	.0544	"
" . . .	0–100	.0559	13
" . . .	23	.05498	2
" . . .	100	.05663	"
" . . .	500	.0581	34
" . . .	17–507	.05987	43
" . . .	800	.076	18
" fluid .	907–1100	.0748	"
Sodium . .	−185–+20	.253	4
Sulphur	−188–+18	0.137	36
" rhombic .	0–54	.1728	33
" monoclin.	0–52	.1809	"
" liquid . .	119–147	.235	2
Tantalum . . .	−185–+20	.033	4
Tellurium . . .	−188–+18	.047	36
" crys. .	15–100	.0483	37
Thallium	−185–+20	.038	4
"	20–100	.0326	27
Thorium	0–100	.0276	38
Tin	−196–−79	.0486	26
"	−76–+18	.0518	"
" cast	21–109	.0551	30
" fluid	250	.05799	18
" "	1100	.0758	"
Titanium	−185–+20	.082	4
"	0–100	.1125	39
Tungsten	−185–+20	.036	4
"	0–100	.0336	40
Uranium	0–98	.028	41
Vanadium . . .	0–100	.1153	40
Zinc	−192–+20	.0836	27
"	20–100	.0931	"
"	0–100	.0935	13.
"	100	.0951	2
"	200	.0996	"
"	300	.1040	"
Zirconium . . .	0–100	.0660	42

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* When one temperature alone is given, the "true" specific heat is given; otherwise, the "mean" specific heat.

Compiled in part from Landolt-Börnstein-Meyerhoffer's Physikalisch-chemische Tabellen.

TABLE 228.—Specific Heat of Water and of Mercury.

Specific Heat of Water.							Specific Heat of Mercury.			
Temperature, °C.	Barnes.	Rowland.	Barnes-Regnault.	Temperature, °C.	Barnes.	Barnes-Regnault.	Temperature, °C.	Specific Heat.	Temperature, °C.	Specific Heat.
−5	1.0155	–	–	60	0.9988	0.9994	0	0.03346	90	0.03277
0	1.0091	–	1.0094	65	.9994	1.0004	5	.03340	100	.03269
+5	1.0050	1.0054	1.0053	70	1.0001	1.0015	10	.03335	110	.03262
10	1.0020	1.0019	1.0023	80	1.0014	1.0042	15	.03330	120	.03255
15	1.0000	1.0000	1.0003	90	1.0028	1.0070	20	.03325	130	.03248
20	0.9987	0.9979	0.9990	100	1.0043	1.0101	25	.03320	140	.03241
25	.9978	.9972	.9981	120	–	1.0162	30	.03316	150	.0324
30	.9973	.9969	.9976	140	–	1.0223	35	.03312	170	.0322
35	.9971	.9981	.9974	160		1.0285	40	.03308	190	.0320
40	.9971	–	.9974	180	–	1.0348	50	.03300	210	.0319
45	.9973	–	.9976	200	–	1.0410	60	.03294	–	–
50	.9977	–	.9980	220	–	1.0476	70	.03289	–	
55	.9982		.9985	–		–	80	.03284		

Barnes's results: Phil. Trans. (A) 199, 1902; Phys. Rev. 15, 1902; 16, 1903. (H thermometer.)
Rowland's as revised by Pernet. (H thermometer.) Barnes-Regnault's as revised by Peabody; Steam Tables.
The mercury data from 0° C to 80, Barnes-Cooke (H thermometer); from 90° to 140, mean of Winklemann, Naccari and Milthaler (air thermometer); above 140°, mean of Naccari and Milthaler.

TABLE 229. — Specific Heat of Various Solids.*

Solid.	Temperature °C.	Specific Heat.	Authority.†
Alloys:			
Bell metal	15-98	0.0858	R
Brass, red	0	.08991	L
" yellow	0	.08831	"
80 Cu+20 Sn	14-98	.0862	R
88.7 Cu+11.3 Al	20-100	.10432	Ln
German silver	0-100	.09464	T
Lipowitz alloy: 24.97 Pb + 10.13 Cd + 50.66 Bi +14.24 Sn	5-50	.0345	M
" "	100-150	.0426	"
Rose's alloy: 27.5 Pb+48.9 Bi+23.6 Sn	—77-20	.0356	S
" "	20-89	.0552	"
Wood's alloy: 25.85 Pb + 6.99 Cd + 52.43 Bi + 14.73 Sn	5-50	.0352	M
" " (fluid)	100-150	.0426	"
Miscellaneous alloys:			
17.5 Sb+29.9 Bi+18.7 Zn+33.9 Sn	20-99	.05657	R
37.1 Sb+62.9 Pb	10-98	.03880	"
39.9 Pb+60.1 Bi	16-99	.03165	P
" " (fluid)	144-358	.03500	"
63.7 Pb+36.3 Sn	12-99	.04073	R
46.7 Pb+53.3 Sn	10-99	.04507	"
63.8 Bi+36.2 Sn	20-99	.04001	"
46.9 Bi+53.1 Sn	20-99	.04504	"
Gas coal	20-1040	.3145	-
Glass, normal thermometer 16^{III}	19-100	.1988	W
" French hard thermometer	-	.1869	Z
" crown	10-50	.161	H M
" flint	10-50	.117	"
Ice	—188-—252	.146	D
"	—78-—188	.285	"
"	—18-—78	.463	"
India rubber (Para)	?-100	.481	G-T
Paraffin	—20-+3	.3768	R W
"	—19-+20	.5251	"
"	0-20	.6939	"
"	35-40	.622	B
" fluid	60-63	.712	"
Vulcanite	20-100	.3312	A M

TABLE 230. — Specific Heat of Various Liquids.*

Liquid.	Temperature °C.	Specific Heat.	Authority.	Liquid.	Temperature °C.	Specific Heat.	Authority.†
Alcohol, ethyl	—20	0.5053	R	Nitrobenzole	28	0.362	A
" "	0	.548	"	Napthalene, $C_{10}H_8$	80-85	.396	B
" "	40	.648	"	"	90-95	.409	"
" methyl	5-10	.590	"	Oils: castor	-	.434	W
" "	15-20	.601	"	citron	5.4	.438	H W
Anilin	15	.514	G	olive	6.6	.471	"
"	30	.520	"	sesame	-	.387	W
"	50	.529	"	turpentine	0	.411	R
Benzole, C_6H_6	10	.340	H-D	Petroleum	21-58	.511	Pa
"	40	.423	"	Toluol, C_6H_8	10	.364	H-D
"	65	.482	"	"	65	.490	"
Diphenylamine, $C_{12}H_{11}N$	53	.464	B	"	85	.534	"
"	65	.482	"	$CaCl_2$, sp. gr. 1.14	—15	.764	DMG
Ethyl ether	0	.529	R	" " "	0	.775	"
Glycerine	15-50	.576	E	" " "	+20	.787	"
Nitrobenzole	14	.350	A	" " 1.20	—20	.695	"

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* These specific heat tables are compiled partly from more extended tables in Landolt-Börnstein-Meyerhoffer's Tables.

† For references see Table 230, page 231.

TABLE 230.—Specific Heat of Various Liquids.

Liquid.	Temperature °C.	Specific Heat.	Authority.	Liquid.	Temperature °C.	Specific Heat.	Authority.
$CaCl_2$, sp. gr. 1.20 .	0	0.712	DMG	$KOH + 30\ H_2O$ . .	18	0.876	TH
“ “ “ .	+20	.725	“	“ $+ 100$ “ . .	18	.975	“
“ “ 1.26 .	−20	.651	“	$NaOH + 50\ H_2O$.	18	.942	“
“ “ “ .	0	.663	“	“ $+ 100$ “ . .	18	.983	“
“ “ “ .	+20	.676	“	$NaCl + 10\ H_2O$ . .	18	.791	“
$CuSo_4 + 50\ H_2O$.	12–15	.848	Pa	“ $+ 200$ “ . .	18	.978	“
“ $+200$ “ .	12–14	.951	“	Sea water, sp. gr. 1.0043	17.5	.980	“
“ $+400$ “ .	13–17	.975	“	“ “ “ 1.0235	17.5	.938	“
$ZnSO_4 + 50\ H_2O$.	20–52	.842	Ma	“ “ “ 1.0463	17.5	.903	“
“ $+200$ “ .	20–52	.952	“				

A, Abbot.
AM, A. M. Mayer.
B, Batelli.
D, Dewar.
E, Emo.
G, Griffiths.
G-T, Gee and Terry.
DMG, Dickinson, Mueller, and George.
H-D, de Heen and Deruyts.
HM, H. Meyer.
L, Lorenz.
Ln, Luginen.
M, Mazotto.
Ma, Marignac.
P, Person.
Pa, Pagliani.
R, Regnault.
RW, R. W. Weber.
T, Tomlison.
S, Schüz.
Th, Thomsen.
W, Wachsmuth.
Wn, Winkelmann.
Z, Zouloff.

TABLE 231.—Specific Heat of Minerals and Rocks.

Substance.	Temperature ° C.	Specific Heat.	Reference.	Substance.	Temperature ° C.	Specific Heat.	Reference.
Andalusite . . .	0–100	0.1684	1	Rock-salt . .	13–45	0.219	6
Anhydrite, $CaSO_4$.	0–100	.1753	1	Serpentine . .	16–98	.2586	2
Apatite	15–99	.1903	2	Siderite . .	9–98	.1934	4
Asbestos . . .	20–98	.195	3	Spinel . . .	15–47	.194	6
Augite	20–98	.1931	3	Talc . . .	20–98	.2092	3
Barite, $BaSO_4$ . .	10–98	.1128	4	Topaz . . .	0–100	.2097	1
Beryl	15–99	.1979	2	Wollastonite .	19–51	.178	6
Borax, $Na_2B_4O_7$ fused	16–98	.2382	4	Zinc blende, ZnS .	0–100	.1146	1
Calcspar, $CaCO_3$ . .	0–50	.1877	1	Zircon . . .	21–51	.132	6
“ “ . .	0–100	.2005	1	Rocks:			
“ “ . .	0–300	.2204	1	Basalt, fine, black	12–100	.1996	6
Casiderite, SnO_3 . .	16–98	.0933	4	“ “ “	20–470	.199	9
Corundum . . .	9–98	.1976	4	“ “ “	470–750	.243	9
Cryolite, $Al_2Fl_3.6NaF$.	16–99	.2522	2	“ “ “	750–880	.626	9
Fluorite, CaF_2 . .	15–99	.2154	4	“ “ “	880–1190	.323	9
Galena, PbS . . .	0–100	.0466	5	Dolomite . .	20–98	.222	3
Garnet	16–100	.1758	2	Gneiss . .	17–99	.196	10
Hematite, Fe_2O_3 . .	15–99	.1645	2	“ . .	17–213	.214	10
Hornblende . . .	20–98	.1952	3	Granite . .	12–100	.192	7
Hypersthene . . .	20–98	.1914	3	Kaolin . .	20–98	.224	3
Labradorite . . .	20–98	.1949	3	Lava, Aetna .	23–100	.201	11
Magnetite . . .	18–45	.156	6	“ “ . .	31–776	.259	11
Malachite, $Cu_2CO_4.H_2O$	15–99	.1763	2	“ Kilauea .	25–100	.197	11
Mica (Mg) . . .	20–98	.2061	3	Limestone . .	15–100	.216	12
“ (K) . . .	20–98	.2080	3	Marble . .	0–100	.21	–
Oligoclase . . .	20–98	.2048	3	Quartz sand .	20–98	.191	3
Orthoclase . . .	15–99	.1877	2	Sandstone . .	–	.22	–
Pyrites, copper . .	15–99	.1291	2				
Pyrolusite, MnO_2 . .	17–48	.159	6				
Quartz, SiO_2 . .	12–100	.188	7				
“ “ . . .	0	.1737	8				
“ “ . . .	350	.2786	8				
“ “ . . .	400–1200	.305	8				

1 Lindner.
2 Oeberg.
3 Ulrich.
4 Regnault.
5 Tilden.
6 Kopp.
7 Joly.
8 Pionchon.
9 Roberts-Austen, Rücker.
10 R. Weber.
11 Bartoli.
12 Morano.

Compiled from Landolt-Börnstein-Meyerhoffer's Physikalisch-chemische Tabellen.

Table 232.

SPECIFIC HEATS OF GASES AND VAPORS.

Substance.	Range of Temp. °C.	Sp. Ht. Constant Pressure.	Authority.	Range of Temp. °C.	Mean Ratio of Specific Heats. C_p/C_v.	Authority.
Acetone, C_8H_6O	26–110	0.3468	Wiedemann.			
“ “	27–179	0.3740	“			
“ “	129–233	0.4125	Regnault.			
Air	−30–+10	0.2377	“	5–14	1.4025	Lummer and Pringsheim.
“	0–100	0.2374	“			
“	0–200	0.2375	“			
“	20–440	0.2366	Holborn and Austin.			
“	20–630	0.2429				
“	20–800	0.2430	“			
Alcohol, C_2H_5OH	108–220	0.4534	Regnault.	53	1.133	Jaeger.
“ “	–	–	–	100	1.134	Stevens.
“ C_2H_8OH	101–223	0.4580	Regnault.	100	1.256	“
Ammonia	23–100	0.5202	Wiedemann.	0	1.3172	Wüllner.
“	27–200	0.5356	“	100	1.2770	“
“	24–216	0.5125	Regnault.			
Argon	20–90	0.1233	Dittenberger.	0	1.667	Niemeyer.
Benzole, C_6H_6	34–115	0.2990	Wiedemann.	20	1.403	Pagliani.
“ “	35–180	0.3325	“	60	1.403	“
“ “	116–218	0.3754	Regnault.	99.7	1.105	Stevens
Bromine	83–228	0.0555	“	20–388	1.293	Strecker.
“	19–388	0.0553	Strecker.			
Carbon dioxide, CO_2	—28–+7	0.1843	Regnault.	4–11	1.2995	Lummer and Pringsheim.
“ “ “	15–100	0.2025	“			
“ “ “	11–214	0.2169	“			
“ monoxide, CO	23–99	0.2425	Wiedemann.	0	1.403	Wüllner.
“ “ “	26–198	0.2426	“	100	1.395	“
“ disulphide, CS_2	86–190	0.1596	Regnault.	3–67	1.205	Beyme.
Chlorine	13–202	0.1241	“	20–340	1.323	Strecker.
“	16–343	0.1125	Strecker.	0	1.336	Martini.
Chloroform, $CHCl_8$	27–118	0.1441	Wiedemann.	22–78	1.102	Beyme.
“ “	28–189	0.1489	“	99.8	1.150	Stevens.
Ether, $C_4H_{10}O$	69–224	0.4797	Regnault.	3–46	1.025	Beyme.
“ “	27–189	0.4618	Wiedemann.	42–45	1.029	Müller.
“ “	25–111	0.4280	“	12–20	1.024	Low.
Hydrochloric acid, HCl	13–100	0.1940	Strecker.	20	1.389	Strecker.
“ “ “	22–214	0.1867	Regnault.	100	1.400	“
Hydrogen	—28–+9	3.3996	“	4–16	1.4080	Lummer and Pringsheim.
“	12–198	3.4090	“			
“	21–100	3.4100	Wiedemann.			
“ sulphide, H_2S	20–206	0.2451	Regnault.	10–40	1.276	Müller.
Methane, CH_4	18–208	0.5929	“	11–30	1.316	“
Nitrogen	0–200	0.2438	“	–	1.41	Cazin.
“	20–440	0.2419	Holborn and Austin.			
“	20–630	0.2464				
“	20–800	0.2497	“			
Nitric oxide, NO	13–172	0.2317	Regnault.			
Nitrogen tetroxide, NO_2	27–67	1.625	Berthelot and Olger.	–	1.31	Natanson.
“ “ “	27–150	1.115				
“ “ “	27–280	0.65	“			
Nitrous oxide, N_2O	16–207	0.2262	Regnault.	0	1.311	Wüllner.
“ “ “	26–103	0.2126	Wiedemann.	100	1.272	“
“ “ “	27–206	0.2241	“			
Oxygen	13–207	0.2175	Regnault.	5–14	1.3977	Lummer and Pringsheim.
“	20–440	0.2240	Holborn and Austin.			
“	20–630	0.2300				
Sulphur dioxide, SO_2	16–202	0.1544	Regnault.	16–34	1.256	Müller.
Water vapor, H_2O	0	0.4655	Thiesen.	78	1.274	Beyme.
“ “ “	100	0.421	“	94	1.33	Jaeger.
“ “ “	180	0.51	“			

THERMOMETERS.

TABLE 233. — Gas and Mercury Thermometers.

If t_H, t_N, t_{002}, t_{16}, t_{59}, t_T, are temperatures measured with the hydrogen, nitrogen, carbonic acid, 16^{III}, 59^{III}, and "verre dur" (Tonnelot), respectively, then

$$t_H - t_T = \frac{(100-t)t}{100^2}[-0.61859 + 0.0047351.t - 0.000011577.t^2]^*$$

$$t_N - t_T = \frac{(100-t)t}{100^2}[-0.55541 + 0.0048240.t - 0.000024807.t^2]^*$$

$$t_{002} - t_T = \frac{(100-t)t}{100^2}[-0.33386 + 0.0039910.t - 0.000016678.t^2]^*$$

$$t_H - t_{16} = \frac{(100-t)t}{100^2}[-0.67039 + 0.0047351.t - 0.000011577.t^2]^\dagger$$

$$t_H - t_{59} = \frac{(100-t)t}{100^2}[-0.31089 + 0.0047351.t - 0.000011577.t^2]^\dagger$$

* Chappuis; Trav. et Mém. du Bur. internat. des Poids et Mes. 6, 1888.

† Thiesen, Scheel, Sell; Wiss. Abh. d. Phys. Techn. Reichanstalt, 2, 1895; Scheel; Wied. Ann. 58, 1896; D. Mech. Ztg. 1897.

TABLE 234. $t_H - t_{16}$ (Hydrogen — 16^{III}).

	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°
0°	.000°	—.007°	—.013°	—.019°	—.025°	—.031°	—.036°	—.042°	—.047°	—.051°
10	—.056	—.061	—.065	—.069	—.073	—.077	—.080	—.084	—.087	—.090
20	—.093	—.096	—.098	—.101	—.103	—.105	—.107	—.109	—.110	—.112
30	—.113	—.114	—.115	—.116	—.117	—.118	—.119	—.119	—.119	—.120
40	—.120	—.120	—.120	—.120	—.119	—.119	—.118	—.118	—.117	—.116
50	—.116	—.115	—.114	—.113	—.111	—.110	—.109	—.107	—.106	—.104
60	—.103	—.101	—.099	—.097	—.096	—.094	—.092	—.090	—.087	—.085
70	—.083	—.081	—.078	—.076	—.074	—.071	—.069	—.066	—.064	—.061
80	—.058	—.056	—.053	—.050	—.048	—.045	—.042	—.039	—.036	—.033
90	—.030	—.027	—.024	—.021	—.018	—.015	—.012	—.009	—.006	—.003
100	.000									

TABLE 235. $t_H - t_{59}$ (Hydrogen — 59^{III}).

	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°
0°	.000°	—.003°	—.006°	—.009°	—.011°	—.014°	—.016°	—.018°	—.020°	—.022°
10	—.024	—.025	—.027	—.028	—.030	—.031	—.032	—.033	—.034	—.035
20	—.035	—.036	—.036	—.037	—.037	—.037	—.038	—.038	—.038	—.038
30	—.038	—.037	—.037	—.037	—.037	—.036	—.036	—.035	—.035	—.034
40	—.034	—.033	—.032	—.032	—.031	—.030	—.029	—.028	—.028	—.027
50	—.026	—.025	—.024	—.023	—.022	—.021	—.020	—.019	—.018	—.017
60	—.016	—.015	—.015	—.014	—.013	—.012	—.011	—.010	—.009	—.008
70	—.008	—.007	—.006	—.005	—.005	—.004	—.003	—.003	—.002	—.001
80	—.001	—.001	.000	.000	+.001	+.001	+.001	+.002	+.002	+.002
90	+.002	+.002	+.002	+.002	+.002	+.002	+.001	+.001	+.001	.000
100	.000									

TABLE 236. (Hydrogen — 16^{III}), (Hydrogen — 59^{III}).

	—5°	—10°	—15°	—20°	—25°	—30°	—35°
$t_H - t_{16}$	+0.04°	+0.08°	+0.13°	+0.19°	+0.25°	+0.32°	+0.40°
$t_H - t_{59}$	+0.02°	+0.04°	+0.07°	+0.10°	+0.14°	+0.18°	+0.23°

All compiled from Landolt-Börnstein-Meyerhoffer's Physikalisch-chemische Tabellen.

AIR AND MERCURY THERMOMETERS.

TABLE 237. $t_{\text{AIR}} - t_{16}$. (Air — 16^{III}.)

°C.	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°
0	.000	—.006	—.012	—.017	—.022	—.027	—.032	—.037	—.041	—.045
10	—.049	—.053	—.057	—.061	—.065	—.068	—.071	—.074	—.077	—.080
20	—.083	—.086	—.089	—.091	—.093	—.095	—.097	—.099	—.101	—.102
30	—.103	—.104	—.105	—.106	—.107	—.108	—.109	—.110	—.110	—.110
40	—.110	—.110	—.111	—.111	—.110	—.110	—.110	—.109	—.109	—.108
50	—.107	—.107	—.106	—.105	—.104	—.103	—.102	—.101	—.100	—.098
60	—.096	—.095	—.093	—.092	—.090	—.088	—.086	—.084	—.082	—.080
70	—.078	—.076	—.074	—.072	—.070	—.067	—.065	—.062	—.060	—.057
80	—.054	—.052	—.049	—.047	—.044	—.041	—.039	—.036	—.034	—.031
90	—.028	—.025	—.023	—.020	—.017	—.014	—.011	—.009	—.006	—.003
100	.000	+.003	+.006	+.008	+.011	+.014	+.017	+.019	+.022	+.025
110	+.028	+.030	+.033	+.035	+.038	+.041	+.043	+.046	+.048	+.050
120	+.053	+.055	+.057	+.060	+.062	+.064	+.066	+.068	+.070	+.072
130	+.074	+.076	+.078	+.080	+.081	+.083	+.084	+.086	+.087	+.089
140	+.090	+.091	+.092	+.093	+.094	+.095	+.096	+.096	+.097	+.097
150	+.098	+.098	+.098	+.099	+.099	+.099	+.098	+.098	+.098	+.097
160	+.097	+.096	+.095	+.094	+.093	+.092	+.090	+.089	+.088	+.086
170	+.084	+.082	+.080	+.078	+.076	+.073	+.071	+.068	+.065	+.062
180	+.059	+.055	+.052	+.048	+.045	+.041	+.037	+.033	+.028	+.023
190	+.019	+.014	+.009	+.004	—.001	—.007	—.013	—.019	—.025	—.031
200	—.038	—.045	—.051	—.058	—.066	—.073	—.080	—.088	—.096	—.105
210	—.113	—.122	—.130	—.139	—.148	—.158	—.168	—.177	—.187	—.198
220	—.208	—.219	—.230	—.241	—.252	—.264	—.275	—.287	—.300	—.312
230	—.325	—.338	—.351	—.365	—.378	—.392	—.407	—.421	—.436	—.450
240	—.466	—.481	—.497	—.513	—.529	—.546	—.562	—.579	—.597	—.614
250	—.632	—.650	—.668	—.687	—.706	—.725	—.745	—.765	—.785	—.805
260	—.825	—.846	—.867	—.889	—.911	—.933	—.955	—.978	—1.001	—1.025
270	—1.048	—1.072	—1.096	—1.121	—1.146	—1.171	—1.196	—1.222	—1.248	—1.274
280	—1.301	—1.328	—1.356	—1.384	—1.412	—1.440	—1.469	—1.498	—1.528	—1.558
290	—1.588	—1.618	—1.649	—1.680	—1.711	—1.743	—1.776	—1.808	—1.841	—1.874
300	—1.908									

TABLE 238. $t_{\text{AIR}} - t_{59}$. (Air — 59^{III}.)

°C.	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°
100	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
110	.000	.000	.000	—.001	—.001	—.001	—.001	—.001	—.002	—.002
120	—.002	—.002	—.002	—.002	—.002	—.003	—.003	—.003	—.004	—.004
130	—.004	—.004	—.005	—.005	—.006	—.006	—.006	—.007	—.007	—.008
140	—.008	—.008	—.009	—.009	—.010	—.010	—.011	—.011	—.012	—.012
150	—.013	—.013	—.014	—.015	—.016	—.016	—.016	—.017	—.018	—.019
160	—.019	—.020	—.021	—.021	—.022	—.023	—.024	—.025	—.026	—.027
170	—.028	—.029	—.030	—.031	—.032	—.033	—.034	—.035	—.037	—.038
180	—.039	—.040	—.041	—.043	—.044	—.045	—.046	—.048	—.049	—.051
190	—.052	—.053	—.055	—.056	—.057	—.059	—.060	—.062	—.064	—.066
200	—.067									

GAS, MERCURY, ALCOHOL, TOLUOL, PETROLETHER, PENTANE, AND PLATINUM-RESISTANCE THERMOMETERS.

TABLE 239. $t^H - t_M$ (Hydrogen-Mercury).

Temperature, C.	Thuringer Glass.*	Verre dur. Tonnelot.†	Resistance Glass.*	English Crystal Glass.*	Choisy-le-Roi.*	122^{III}.*	Nitrogen Thermometer. $T_H - T_N$.†	CO_2 Thermometer. $T_H - T_{CO_2}$.†
°	°	°	°	°	°	°	°	°
0	.000	.000	.000	.000	.000	.000	.000	.000
10	—.075	—.052	—.066	—.008	—.007	—.005	—.006	—.025
20	—.125	—.085	—.108	—.001	—.004	—.006	—.010	—.043
30	—.156	—.102	—.131	+.017	+.004	—.002	—.011	—.054
40	—.168	—.107	—.140	+.037	+.014	+.001	—.011	—.059
50	—.166	—.103	—.135	+.057	+.025	+.004	—.009	—.059
60	—.150	—.090	—.119	+.073	+.033	+.008	—.005	—.053
70	—.124	—.072	—.095	+.079	+.037	+.009	—.001	—.044
80	—.088	—.050	—.068	+.070	+.032	+.007	+.002	—.031
90	—.047	—.026	—.034	+.046	+.022	+.006	+.003	—.016
100	.000	.000	.000	.000	.000	.000	.000	.000

* Schlösser, Zt. Instrkde. 21, 1901. † Chappuis, Trav. et mém. du Bur. Intern. des Poids et Mes. 6, 1888.

TABLE 240.—Comparison of Air and High Temperature Mercury Thermometers.

Comparison of the air thermometer with the high temperature mercury thermometer, filled under pressure and made of 59^{III} glass.

Air.	59^{III}.	Air.	59^{III}.
°	°	°	°
0	0.	375	385.4
100	100.	400	412.3
200	200.4	425	440.7
300	304.1	450	469.1
325	330.9	475	498.0
350	358.1	500	527.8

Mahlke, Wied. Ann. 1894.

TABLE 241.—Comparison of Hydrogen and Other Thermometers.

Comparison of the hydrogen thermometer with the toluol, alcohol, petrolether, and pentane thermometers (verre dur).

Hydrogen.	Toluol.*	Alcohol I.*	Alcohol II.*	Petrolether.†	Pentane.‡
°	°	°	°	°	°
0	0.00	0.00	0.00	-	0.00
—10	—8.54	—9.31	—9.44	-	—9.03
—20	—16.90	—18.45	—18.71	-	—17.87
—30	—25.10	—27.44	—27.84	-	—26.55
—40	—33.15	—36.30	—36.84	-	—35.04
—50	—41.08	—45.05	—45.74	—42.6	—43.36
—60	—48.90	—53.71	—54.55	-	—51.50
—70	—56.63	—62.31	—63.31	-	—59.46
—100	-	-	-	—80.2	—82.28
—150	-	-	-	—113.0	—116.87
—200	-	-	-	—140.7	—146.84

* Chappuis, Arch. sc. phys. (3) 18, 1892. † Holborn, Ann. d. Phys. (4) 6, 1901. ‡ Rothe, unpublished.

All compiled from Landolt-Börnstein-Meyerhoffer's Physikalisch-chemische Tabellen.

CORRECTION FOR TEMPERATURE OF MERCURY IN THERMOMETER STEM.

The Stem Correction is proportional to $n\beta(T-t)$: where n is the number of degrees in the exposed stem; β is the apparent coefficient of expansion of mercury in the glass; T is the measured temperature; and t is the mean temperature of the exposed stem determined by another thermometer, exposed some 10 cm. from, and at about half the height of, the exposed stem of the first.

For temperatures up to 100°C, the value of β is for:

Jena glass XVI$^{\text{III}}$ or Greiner and Friedrich resistance glass, $\frac{1}{6300}$ or 0.000159;

Jena glass 59$^{\text{III}}$, $\frac{1}{6100}$ or 0.000164.

At 100° the correction is in round numbers 0.01° for each degree of the exposed stem; at 200° 0.02°; and for higher temperatures proportionately greater. At 500° it may amount to 0.07° for each exposed degree.

Tables 242–244 are taken from Rimbach, Zeitschrift für Instrumentenkunde, 10, 153, 1890, and apply to thermometers of Jena or of resistance glass.

TABLE 242. — Stem Correction for Thermometer of Jena Glass (0°–360° C.).

Degree length 0.9 to 1.1 mm; t = the observed temperature; t' = that of the surrounding air 1 dm. away; n = the length of the exposed thread.

	Correction to be added to the Reading t.									
	$t - t'$									
n	70°	80°	90°	100°	120°	140°	160°	180°	200°	220°
10	0.01	0.01	0.03	0.04	0.07	0.10	0.13	0.17	0.19	0.21
20	0.08	0.12	0.14	0.19	0.25	0.28	0.32	0.40	0.49	0.54
30	0.25	0.28	0.32	0.36	0.42	0.48	0.54	0.66	0.78	0.87
40	0.30	0.35	0.41	0.48	0.60	0.67	0.77	0.92	1.08	1.20
50	0.41	0.46	0.52	0.59	0.79	0.89	0.98	1.16	1.38	1.53
60	0.52	0.60	0.68	0.79	0.99	1.11	1.23	1.46	1.70	1.87
70	0.63	0.74	0.85	0.98	1.20	1.32	1.45	1.70	1.99	2.21
80	0.75	0.87	1.01	1.15	1.38	1.53	1.70	1.98	2.29	2.54
90	0.87	0.99	1.13	1.28	1.62	1.82	1.94	1.25	2.60	2.89
100	0.98	1.12	1.29	1.47	1.82	2.03	2.20	2.55	2.92	3.24
120	–	–	–	1.88	2.28	2.49	2.68	3.13	3.59	3.96
140	–	–	–	–	2.75	2.97	3.22	3.75	4.24	4.69
160	–	–	–	–	–	3.35	3.80	4.35	4.92	5.45
180	–	–	–	–	–	–	4.37	4.99	5.63	6.22
200	–	–	–	–	–	–	–	5.68	6.34	6.98
220	–	–	–	–	–	–	–	–	7.05	7.82

CORRECTION FOR TEMPERATURE OF MERCURY IN THERMOMETER STEM (*continued*).

TABLE 243. — Stem Correction for Thermometer of Jena Glass (0°–360° C).

Degree length 1 to 1.6 mm.; t = the observed temperature; t' = that of the surrounding air one dm. away; n = the length of the exposed thread.

CORRECTION TO BE ADDED TO THERMOMETER READING.*

n	$t-t'$										n
	70°	80°	90°	100°	120°	140°	160°	180°	200°	220°	
10°	0.02	0.03	0.05	0.07	0.11	0.17	0.21	0.27	0.33	0.38	10°
20	0.13	0.15	0.18	0.22	0.29	0.38	0.46	0.53	0.61	0.67	20
30	0.24	0.28	0.33	0.39	0.48	0.59	0.70	0.78	0.88	0.97	30
40	0.35	0.41	0.48	0.56	0.68	0.82	0.94	1.04	1.16	1.28	40
50	0.47	0.53	0.62	0.72	0.88	1.03	1.17	1.31	1.44	1.59	50
60	0.57	0.66	0.77	0.89	1.09	1.25	1.42	1.58	1.74	1.90	60
70	0.69	0.79	0.92	1.06	1.30	1.47	1.67	1.86	2.04	2.23	70
80	0.80	0.91	1.05	1.21	1.52	1.71	1.94	2.15	2.33	2.55	80
90	0.91	1.04	1.19	1.38	1.73	1.96	2.20	2.42	2.64	2.89	90
100	1.02	1.18	1.35	1.56	1.97	2.18	2.45	2.70	2.94	3.23	100
110	–	–	–	1.78	2.19	2.43	2.70	2.98	3.26	3.57	110
120	–	–	–	1.98	2.43	2.69	2.95	3.26	3.58	3.92	120
130	–	–	–	–	2.68	2.94	3.20	3.56	3.89	4.28	130
140	–	–	–	–	2.92	3.22	3.47	3.86	4.22	4.64	140
150	–	–	–	–	–	–	3.74	4.15	4.56	5.01	150
160	–	–	–	–	–	–	4.00	4.46	4.90	5.39	160
170	–	–	–	–	–	–	4.27	4.76	5.24	5.77	170
180	–	–	–	–	–	–	4.54	5.07	5.59	6.15	180
190	–	–	–	–	–	–	–	5.38	5.95	6.54	190
200	–	–	–	–	–	–	–	5.70	6.30	6.94	200
210	–	–	–	–	–	–	–	–	6.68	7.35	210
220	–	–	–	–	–	–	–	–	7.04	7.75	220

* See Hovestadt's "Jena Glass" (translated by J. D. and A. Everett) for data on changes of thermometer zeros.

TABLE 244. — Stem Correction for a so-called Normal Thermometer of Jena Glass (0°–100° C).

Divided into tenth degrees; degree length about 4 mm.

CORRECTION TO BE ADDED TO THE READING t.

n	$t-t'$											
	30°	35°	40°	45°	50°	55°	60°	65°	70°	75°	80°	85°
10	0.04	0.04	0.05	0.05	0.05	0.06	0.06	0.07	0.08	0.09	0.10	0.10
20	0.12	0.12	0.13	0.14	0.15	0.16	0.17	0.18	0.19	0.20	0.22	0.23
30	0.21	0.22	0.23	0.24	0.25	0.25	0.27	0.29	0.31	0.33	0.35	0.37
40	0.28	0.29	0.31	0.33	0.35	0.37	0.39	0.41	0.43	0.45	0.48	0.51
50	0.36	0.38	0.40	0.42	0.44	0.46	0.48	0.50	0.53	0.57	0.61	0.65
60	0.45	0.48	0.51	0.53	0.55	0.57	0.60	0.63	0.66	0.69	0.73	0.78
70	–	–	–	–	–	0.66	0.69	0.71	0.75	0.81	0.87	0.92
80	–	–	–	–	–	–	0.76	0.81	0.87	0.93	1.00	1.06
90	–	–	–	–	–	–	–	0.92	0.99	1.06	1.13	1.20
100	–	–	–	–	–	–	–	–	1.10	1.18	1.26	1.34

RADIATION CONSTANTS.

TABLE 245. — Radiation Formulæ and Constants for Perfect Radiator.

The radiation per sq. cm. from a "black body" (exclusive of convection losses) at the temperature $T°$ (absolute, C) to one at $t°$ is equal to

$$J = \sigma\,(T^4 - t^4) \quad \text{(Stefan-Boltzmann)};$$

where $\sigma = 1.277 \times 10^{-12}$ gramme-calories per second per sq. centimetre.
$= 7.66 \times 10^{-11}$ " " " minute " " "
$= 5.32 \times 10^{-12}$ watts per sq. centimetre.

The distribution of this energy in the spectrum is represented by Planck's formula:

$$J_\lambda = C_1 \lambda^{-5} \left[e^{\frac{C_2}{\lambda T}} - 1 \right]^{-1}$$

where J_λ is the intensity of the energy at the wave-length λ (λ expressed in microns, μ) and e is the base of the Napierian logarithms. From Kurlbaum's value of the difference of the total energy radiated from black bodies at 100° C and 0° C, $J_{100} - J_0 = 0.0731$ watts per square centimetre (whence the above value of σ) and $\lambda_{\max} T = 2930$ (the mean of Paschen's and Lummer's values), the following constants have been calculated (see Planck, Ann. d. Phys. 4, p. 562, 1901):

$C_1 = 8.813 \times 10^8$ for J in $\frac{gram.\ cal.}{sec.\ cm.^2} = 3.688 \times 10^4$ for J in $\frac{watts}{cm.^2}$

$C_2 = 14550$ for λ in microns (μ)

$J_{\max} = 2.869 \times 10^{-16}\, T^5$ for J in $\frac{gram.\ cal.}{sec.\ cm.^2} = 1.200 \times 10^{-15} T^5$ for J in $\frac{watts}{cm.^2}$

$\lambda_{\max} T = 2930$ for λ in microns (μ).

TABLE 246. — Radiation in Gramme-Calories per 24 Hours from a Perfect Radiator at $t°$ C to an absolutely Cold Space (—273° C).

Computed from the Stefan-Boltzmaon formula (Ekholm, Met. Z 1902).

$t°$ C	J	$t°$ C	J	$t°$ C	J	$t°$ C	J	$t°$ C	J	$t°$ C	J
—273	0	—120	60	—10	528	+12	728	+34	980	+56	1292
—220	1	—110	78	—8	544	+14	748	+36	1006	+58	1324
—210	2	—100	99	—6	561	+16	769	+38	1032	+60	1356
—200	3	—90	124	—4	578	+18	791	+40	1059	+70	1530
—190	5	—80	153	—2	595	+20	813	+42	1086	+80	1713
—180	8	—70	187	0	613	+22	836	+44	1114	+90	1916
—170	12	—60	227	+2	631	+24	859	+46	1142	+100	2134
—160	18	—50	273	+4	649	+26	882	+48	1171	+200	5519
—150	25	—40	324	+6	668	+28	906	+50	1201	+1000	290×10^8
—140	35	—30	385	+8	688	+30	930	+52	1231	+2000	294×10^4
—130	46	—20	452	+10	708	+32	955	+54	1261	+5000	852×10^5

TABLE 247. — Values of J_λ for Various Temperatures Centigrade.

Ekholm, Met. Z. 1902, used $C_1 = 8346 \times 10$ and $C_2 = 14349$, and for the unit of time the day.
For 10°, the values for J_λ have been multiplied by 10, for the other temperatures by 100.

λ	T = 100° C	30° C	15° C	0° C	—30° C	—80° C	λ	100° C	30° C	15° C	0° C	—30° C	—80° C
μ							μ						
2	1	0	0	0	0	0	18	511	2961	2557	2175	1491	623
3	80	41	18	7	1	0	19	443	2626	2281	1954	1363	594
4	469	508	272	138	27	1	20	386	2329	2034	1754	1242	561
5	1047	1777	1085	628	172	8	21	337	2068	1816	1574	1129	527
6	1526	3464	2296	1454	493	39	22	295	1840	1622	1413	1026	494
7	1768	4954	3481	2353	931	105	23	259	1639	1448	1270	931	460
8	1810	5928	4352	3088	1372	203	24	228	1462	1298	1141	846	428
9	1724	6382	4834	3646	1730	316	25	202	1307	1165	1028	768	398
10	1573	6386	4979	3781	1971	426	26	179	1170	1047	926	698	369
11	1398	6127	4833	3798	2098	520	28	142	947	850	757	579	317
12	1225	5712	4633	3676	2114	592	30	114	771	696	623	482	272
13	1063	5222	4300	3467	2090	640	40	44	311	285	259	209	130
14	918	4713	3930	3215	2004	666	50	20	146	135	124	102	67
15	792	4220	3556	2944	1889	673	60	10	77	72	66	55	38
16	683	3759	3198	2674	1760	663	80	4	27	25	24	20	14
17	590	3340	2862	2417	1626	649	100	2	12	11	10	9	7

COOLING BY RADIATION AND CONVECTION.

TABLE 248. — At Ordinary Pressures.

According to McFarlane* the rate of loss of heat by a sphere placed in the centre of a spherical enclosure which has a blackened surface, and is kept at a constant temperature of about 14° C, can be expressed by the equation

$$e = .000238 + 3.06 \times 10^{-6}t - 2.6 \times 10^{-8}t^2,$$

when the surface of the sphere is blackened, or

$$e = .000168 + 1.98 \times 10^{-6}t - 1.7 \times 10^{-8}t^2,$$

when the surface is that of polished copper. In these equations, e is the amount of heat lost in c. g. s. units, that is, the quantity of heat, small calories, radiated per second per square centimetre of surface of the sphere, per degree difference of temperature t, and t is the difference of temperature between the sphere and the enclosure. The medium through which the heat passed was moist air. The following table gives the results.

Difference of temperature t	Value of e.		Ratio.
	Polished surface.	Blackened surface.	
5	.000178	.000252	.707
10	.000186	.000266	.699
15	.000193	.000279	.692
20	.000201	.000289	.695
25	.000207	.000298	.694
30	.000212	.000306	.693
35	.000217	.000313	.693
40	.000220	.000319	.693
45	.000223	.000323	.690
50	.000225	.000326	.690
55	.000226	.000328	.690
60	.000226	.000328	.690

TABLE 249. — At Different Pressures.

Experiments made by J. P. Nicol in Tait's Laboratory show the effect of pressure of the enclosed air on the rate of loss of heat. In this case the air was dry and the enclosure kept at about 8° C.

Polished surface.		Blackened surface.	
t	et	t	et
PRESSURE 76 CMS. OF MERCURY.			
63.8	.00987	61.2	.01746
57.1	.00862	50.2	.01360
50.5	.00736	41.6	.01078
44.8	.00628	34.4	.00860
40.5	.00562	27.3	.00640
34.2	.00438	20.5	.00455
29.6	.00378	–	–
23.3	.00278	–	–
18.6	.00210	–	–
PRESSURE 10.2 CMS. OF MERCURY.			
67.8	.00492	62.5	.01298
61.1	.00433	57.5	.01158
55	.00383	53.2	.01048
49.7	.00340	47.5	.00898
44.9	.00302	43.0	.00791
40.8	.00268	28.5	.00490
PRESSURE 1 CM. OF MERCURY.			
65	.00388	62.5	.01182
60	.00355	57.5	.01074
50	.00286	54.2	.01003
40	.00219	41.7	.00726
30	.00157	37.5	.00639
23.5	.00124	34.0	.00569
–	–	27.5	.00446
–	–	24.2	.00391

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* "Proc. Roy. Soc." 1872.

† "Proc. Roy. Soc." Edinb. 1869.

See also Compan, Annal. de chi. et phys. 26, p. 526.

COOLING BY RADIATION AND CONVECTION.

TABLE 250. — Cooling of Platinum Wire in Copper Envelope.

Bottomley gives for the radiation of a bright platinum wire to a copper envelope when the space between is at the highest vacuum attainable the following numbers: —

$t = 408°$ C., $et = 378.8 \times 10^{-4}$, temperature of enclosure 16° C.
$t = 505°$ C., $et = 726.1 \times 10^{-4}$, " " 17° C.

It was found at this degree of exhaustion that considerable relative change of the vacuum produced very small change of the radiating power. The curve of relation between degree of vacuum and radiation becomes asymptotic for high exhaustions. The following table illustrates the variation of radiation with pressure of air in enclosure.

Temp. of enclosure 16° C., $t = 408°$ C.		Temp. of enclosure 17° C., $t = 505°$ C.	
Pressure in mm.	*et*	Pressure in mm.	*et*
740.	8137.0×10^{-4}	0.094	1688.0×10^{-4}
440.	7971.0 "	.053	1255.0 "
140.	7875.0 "	.034	1126.0 "
42.	7591.0 "	.013	920.4 "
4.	6036.0 "	.0046	831.4 "
0.444	2683.0 "	.00052	767.4 "
.070	1045.0 "	.00019	746.4 "
.034	727.3 "	Lowest reached but not measured	726.1 "
.012	539.2 "		
.0051	436.4 "		
.00007	378.8 "		

TABLE 251. — Effect of Pressure on Loss of Heat at Different Temperatures.

The temperature of the enclosure was about 15° C. The numbers give the total radiation in therms per square centimetre per second.

Temp. of wire in C°.	Pressure in mm.				
	10.0	1.0	0.25	0.025	About 0.1 M.
100°	0.14	0.11	0.05	0.01	0.005
200	.31	.24	.11	.02	.0055
300	.50	.38	.18	.04	.0105
400	.75	.53	.25	.07	.025
500	–	.69	.33	.13	.055
600	–	.85	.45	.23	.13
700	–	–	–	.37	.24
800	–	–	–	.56	.40
900	–	–	–	–	.61

NOTE. — An interesting example (because of its practical importance in electric lighting) of the effect of difference of surface condition on the radiation of heat is given on the authority of Mr. Evans and himself in Bottomley's paper. The energy required to keep up a certain degree of incandescence in a lamp when the filament is dull black and when it is "flashed" with coating of hard bright carbon, was found to be as follows: —

Dull black filament, 57.9 watts.
Bright " " 39.8 watts.

TABLE 252.

PROPERTIES OF STEAM.

Metric Measure.

The temperature Centigrade and the absolute temperature in degrees Centigrade, together with other data for steam or water vapor stated in the headings of the columns, are here given. The quantities of heat are in therms or calories according as the gramme or the kilogramme is taken as the unit of mass.

Temp. C.	Absolute temp.	Pressure in mm. of mercury.	Pressure in grammes per sq. centimetre $= p$.	Pressure in atmospheres.	Total heat of evaporation from 0° at $t° = H$.	Heat of liquid $= h$.	Heat of evaporation $= H - h$.	Outer latent or external-work heat $= Apv$.*	Total heat of steam $= H - Apv$.	Inner latent or internal-work heat $= H - (h + Apv)$.	Litres per gramme, or cubic metres per kilog. $= v$.	Ratio of inner latent heat to volume of steam.†
0°	273	4.60	6.25	0.006	606.5	0.00	606.5	31.07	575.4	575.4	210.66	2.732
5	278	6.53	8.88	.009	608.0	5.00	603.0	31.47	576.5	571.5	150.23	3.805
10	283	9.17	12.47	.012	609.5	10.00	599.5	31.89	577.7	567.7	108.51	5.231
15	288	12.70	17.27	.017	611.1	15.00	596.0	32.32	578.8	563.7	79.35	7.104
20	293	17.39	23.64	.023	612.6	20.01	592.6	32.75	579.8	559.8	78.72	9.532
25	298	23.55	32.02	0.031	614.1	25.02	589.1	33.20	580.9	555.9	43.96	12.64
30	303	31.55	42.89	.042	615.6	30.03	585.6	33.66	582.0	552.0	33.27	16.59
35	308	41.83	56.87	.055	617.2	35.04	582.1	34.12	583.1	548.2	25.44	21.54
40	313	54.91	74.65	.072	618.7	40.05	587.6	34.59	584.1	544.1	19.64	27.70
45	318	71.39	97.06	.094	620.2	45.07	575.1	35.06	585.2	540.1	15.31	35.26
50	323	91.98	125.0	0.121	621.7	50.09	571.7	35.54	586.2	536.1	12.049	44.49
55	328	117.47	159.7	.155	623.3	55.11	568.2	36.02	587.2	532.1	9.561	55.65
60	333	148.79	202.3	.196	624.8	60.13	564.7	36.51	588.3	528.1	7.653	69.02
65	338	186.94	254.2	.246	626.3	65.17	561.1	37.00	589.3	524.2	6.171	84.94
70	343	233.08	316.9	.306	627.8	70.20	557.6	37.48	590.4	520.2	5.014	103.75
75	348	288.50	392.3	0.380	629.4	75.24	554.1	37.96	591.4	516.2	4.102	125.8
80	353	354.62	482.1	.446	630.9	80.28	550.6	38.42	592.5	512.2	3.379	151.6
85	358	433.00	588.7	.570	632.4	85.33	547.1	38.88	593.5	508.2	2.800	181.5
90	363	525.39	714.4	.691	633.9	90.38	543.6	39.33	594.6	504.2	2.334	216.0
95	368	633.69	861.7	.834	635.5	95.44	540.0	39.76	595.7	500.3	1.957	255.7
100	373	760.00	1033.	1.000	637.0	100.5	536.5	40.20	596.8	496.3	1.6496	300.8
105	378	906.41	1232.	.193	638.5	105.6	533.0	40.63	597.9	492.3	1.3978	352.2
110	383	1075.4	1462.	.415	640.0	110.6	529.4	41.05	599.0	488.4	1.1903	410.3
115	388	1269.4	1726.	.670	641.6	115.7	525.8	41.46	600.1	484.4	1.0184	475.6
120	393	1491.3	2027.	.962	643.1	120.8	522.3	41.86	601.2	480.4	0.8752	549.0
125	398	1743.9	2371.	2.295	644.6	125.9	518.7	42.25	602.4	476.5	0.7555	630.7
130	403	2030.3	2760.	2.671	646.1	131.0	515.1	42.63	603.5	472.5	0.6548	721.6
135	408	2353.7	3200.	3.097	647.7	136.1	511.6	43.01	604.7	468.6	0.5698	822.3
140	413	2717.6	3695.	3.576	649.2	141.2	508.0	43.38	605.8	464.6	0.4977	933.5
145	418	3125.6	4249.	4.113	650.7	146.3	504.4	43.73	607.0	460.7	0.4363	1055.7
150	423	3581.2	4869.	4.712	652.2	151.5	500.8	44.09	608.2	456.7	0.3839	1190.
155	428	4088.6	5589.	5.380	653.8	156.5	497.2	44.43	609.3	452.8	0.3388	1336.
160	433	4651.6	6324.	6.120	655.3	161.7	493.5	44.76	610.5	448.8	0.3001	1496.
165	438	5274.5	7171.	6.940	656.8	166.9	489.9	45.09	611.7	444.8	0.2665	1669.
170	443	5961.7	8105.	7.844	658.3	172.0	486.3	45.40	612.9	440.9	0.2375	1856.
175	448	6717.4	9133.	8.839	659.9	177.2	482.7	45.71	614.2	436.9	0.2122	2059.
180	453	7546.4	10260.	9.929	661.4	182.4	479.0	46.01	615.4	433.0	0.1901	2277.
185	458	8453.2	11490.	11.123	662.9	187.6	475.3	46.30	616.6	429.0	0.1708	2512.
190	463	9442.7	12838.	12.425	664.4	192.8	471.7	46.59	617.9	425.0	0.1538	2763.
195	468	10520.	14303.	13.842	666.0	198.0	468.0	46.86	619.1	421.1	0.1389	3031.
200	473	11689.	15892.	15.380	667.5	203.2	464.3	47.13	620.4	417.1	0.1257	3318.

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* Where A is the reciprocal of the mechanical equivalent of the thermal unit.

† $= \frac{H - (h + Apv)}{v} = \frac{\text{internal-work pressure}}{\text{mechanical equivalent of heat}}$. Where v is taken in litres the pressure is given per square decimetre, and where v is taken in cubic metres the pressure is given per square metre, — the mechanical equivalent being that of the therm and the kilogramme-degree or calorie respectively.

TABLE 253.

PROPERTIES OF STEAM.

British Measure.

The quantities given in the different columns of this table are sufficiently explained by the headings. The abbreviation B. T. U. stands for British thermal units. With the exception of column 3, which was calculated for this table, the data are taken from a table given by Dwelshauvers-Dery (Trans. Am. Soc. Mech. Eng. vol. xi.).

Pressure in pounds per square inch.	Pressure in pounds per square foot.	Pressure in atmospheres.	Temp. in degrees Fahr.	Volume per pound in cubic feet.	Weight per cubic foot in pounds.	Heat of water per pound in B. T. U.	Internal latent heat per pound of steam in B. T. U.	External latent heat per pound of steam in B. T. U.	Total latent heat per pound of steam in B. T. U.	Total heat per pound of steam in B. T. U.
1	144	0.068	102.0	334.23	0.0030	70.1	980.6	62.34	1043.	1113.0
2	288	.136	126.3	173.23	.0058	94.4	961.4	64.62	1026.	1120.4
3	432	.204	141.6	117.98	.0085	109.9	949.2	66.58	1011.	1127.0
4	576	.272	153.1	89.80	.0111	121.4	940.2	67.06	1007.	1128.6
5	720	.340	162.3	72.50	.0137	130.7	932.8	67.89	1001.	1131.4
6	864	0.408	170.1	61.10	0.0163	138.6	926.7	68.58	995.2	1133.8
7	1008	.476	176.9	53.00	.0189	145.4	921.3	69.18	990.5	1135.9
8	1152	.544	182.9	46.60	.0214	151.5	916.5	69.71	986.2	1137.7
9	1296	.612	188.3	41.82	.0239	156.9	912.2	70.18	982.4	1139.4
10	1440	.680	193.2	37.80	.0264	161.9	908.3	70.61	979.0	1140.9
11	1584	0.748	197.8	34.61	0.0289	166.5	904.8	70.99	975.8	1142.3
12	1728	.816	202.0	31.90	.0314	170.7	901.5	71.34	972.8	1143.5
13	1872	.884	205.9	29.58	.0338	174.7	898.4	71.68	970.0	1144.7
14	2016	.952	209.5	27.59	.0362	178.4	895.4	72.00	967.4	1145.9
15	2160	1.020	213.0	25.87	.0387	181.9	892.7	72.29	965.0	1146.9
16	2304	1.088	216.3	24.33	0.0411	185.2	890.1	72.57	962.7	1147.9
17	2448	.156	219.4	22.98	.0435	188.4	887.6	72.82	960.4	1148.9
18	2592	.224	222.4	21.78	.0459	191.4	885.3	73.07	958.3	1149.8
19	2736	.292	225.2	20.70	.0483	194.3	883.1	73.30	956.3	1150.6
20	2880	.360	227.9	19.72	.0507	197.0	880.9	73.53	954.4	1151.4
21	3024	1.429	230.5	18.84	0.0531	199.7	878.8	73.74	952.6	1152.2
22	3168	.497	233.0	18.03	.0554	202.2	876.8	73.94	950.8	1153.0
23	3312	.565	235.4	17.30	.0578	204.7	874.9	74.13	949.1	1153.7
24	3456	.633	237.7	16.62	.0602	207.0	873.1	74.32	947.4	1154.4
25	3600	.701	240.0	15.99	.0625	209.3	871.3	74.51	945.8	1155.1
26	3744	1.769	242.2	15.42	0.0649	211.5	869.6	74.69	944.3	1155.8
27	3888	.837	244.3	14.88	.0672	213.7	867.9	74.85	942.8	1156.4
28	4032	.905	246.3	14.38	.0695	215.7	866.3	75.01	941.3	1157.1
29	4176	.973	248.3	13.91	.0619	217.8	864.7	75.17	939.9	1157.7
30	4320	2.041	250.2	13.48	.0742	219.7	863.2	75.33	938.5	1158.3
31	4464	2.109	252.1	13.07	0.0765	221.6	861.7	75.47	937.2	1158.8
32	4608	.177	253.9	12.68	.0788	223.5	860.3	75.61	935.9	1159.4
33	4752	.245	255.7	12.32	.0811	225.3	858.9	75.76	934.6	1159.9
34	4896	.313	257.5	11.98	.0835	227.1	857.5	75.89	933.4	1160.5
35	5040	.381	259.2	11.66	.0858	228.8	856.1	76.02	932.1	1161.0
36	5184	2.449	260.8	11.36	0.0881	230.5	854.8	76.16	931.0	1161.5
37	5328	.517	262.5	11.07	.0903	232.2	853.5	76.28	929.8	1162.0
38	5472	.585	264.0	10.79	.0926	233.8	852.3	76.40	928.7	1162.5
39	5616	.653	265.6	10.53	.0949	235.4	851.0	76.52	927.6	1162.9
40	5760	.722	267.1	10.29	.0972	236.9	849.8	76.63	926.5	1163.4
41	5904	2.789	268.6	10.05	0.0995	238.5	848.7	76.75	925.4	1163.9
42	6048	.857	270.1	9.83	.1018	239.9	847.5	76.86	924.4	1164.3
43	6192	.925	271.5	9.61	.1040	241.4	846.4	76.97	923.3	1164.7
44	6336	.993	272.9	9.41	.1063	242.9	845.2	77.07	922.3	1165.2
45	6480	3.061	274.3	9.21	.1086	244.3	844.1	77.18	921.3	1165.6
46	6624	3.129	275.6	9.02	0.1108	245.6	843.1	77.29	920.4	1166.0
47	6768	.197	277.0	8.84	.1131	247.0	842.0	77.39	919.4	1166.4
48	6912	.265	278.3	8.67	.1153	248.3	841.0	77.49	918.5	1166.8
49	7056	.333	279.6	8.50	.1176	249.7	840.0	77.58	917.5	1167.2

TABLE 253 (*continued*).

PROPERTIES OF STEAM.

British Measure.

Pressure in pounds per square inch.	Pressure in pounds per square foot.	Pressure in atmospheres.	Temp. in degrees Fahr.	Volume per pound in cubic feet.	Weight per cubic foot in pounds.	Heat of water per pound in B. T. U.	Internal latent heat per pound of steam in B. T. U.	External latent heat per pound of steam in B. T. U.	Total latent heat per pound of steam in B. T. U.	Total heat per pound of steam in B. T. U.
50	7200	3.401	280.8	8.34	0.1198	251.0	839.0	77.67	916.6	1167.6
51	7344	.469	282.1	8.19	.1221	252.2	838.0	77.76	915.7	1168.0
52	7488	.537	283.3	8.04	.1243	253.5	837.0	77.85	914.9	1168.3
53	7632	.605	284.5	7.90	.1266	254.7	836.0	77.94	914.0	1168.7
54	7776	.673	285.7	7.76	.1288	256.0	835.1	78.03	913.1	1169.1
55	7920	3.741	286.9	7.63	0.1310	257.1	834.2	78.12	912.3	1169.4
56	8064	.801	288.1	7.50	.1333	258.3	833.2	78.21	911.5	1169.8
57	8208	.878	289.2	7.38	.1355	259.5	832.3	78.29	910.6	1170.1
58	8352	.946	290.3	7.26	.1377	260.7	831.5	78.37	909.8	1170.5
59	8496	4.014	291.4	7.14	.1400	261.8	830.6	78.45	909.0	1170.8
60	8640	4.082	292.5	7.03	0.1422	262.9	829.7	78.53	908.2	1171.2
61	8784	.150	293.6	6.92	.1444	264.0	828.9	78.61	907.5	1171.5
62	8928	.218	294.7	6.82	.1466	265.1	828.0	78.68	906.7	1171.8
63	9072	.286	295.7	6.72	.1488	266.1	827.2	78.76	905.9	1172.1
64	9216	.354	296.7	6.62	.1511	267.2	826.4	78.83	905.2	1172.4
65	9360	4.422	297.8	6.52	0.1533	268.3	825.6	78.90	904.5	1172.8
66	9504	.490	298.8	6.43	.1555	269.3	824.8	78.97	903.7	1173.1
67	9648	.558	299.8	6.34	.1577	270.4	824.0	79.04	903.1	1173.4
68	9792	.626	300.1	6.25	.1599	271.4	823.2	79.11	902.3	1173.7
69	9936	.694	301.8	6.17	.1621	272.4	822.4	79.18	901.6	1174.0
70	10080	4.762	302.7	6.09	0.1643	273.4	821.6	79.25	900.9	1174.3
71	10224	.830	303.7	6.00	.1665	274.3	820.9	79.32	900.2	1174.6
72	10368	.898	304.6	5.93	.1687	275.3	820.1	79.39	899.5	1174.9
73	10512	.966	305.5	5.85	.1709	276.3	819.4	79.46	898.8	1175.1
74	10656	5.034	306.5	5.78	.1731	277.2	818.7	79.53	898.1	1175.4
75	10800	5.102	307.4	5.70	0.1753	278.2	817.9	79.59	897.5	1175.7
76	10944	.170	308.3	5.63	.1775	279.1	817.2	79.65	896.9	1176.0
77	11088	.238	309.2	5.57	.1797	280.0	816.5	79.71	896.2	1176.2
78	11232	.306	310.1	5.50	.1818	280.9	815.8	79.77	895.6	1176.5
79	11376	.374	310.9	5.43	.1840	281.8	815.1	79.83	895.0	1176.8
80	11520	5.442	311.8	5.37	0.1862	282.7	814.4	79.89	894.3	1177.0
81	11664	.510	312.7	5.31	.1884	283.6	813.8	79.95	893.7	1177.3
82	11808	.578	313.5	5.25	.1906	284.5	813.0	80.01	893.1	1177.6
83	11952	.646	314.4	5.19	.1928	285.3	812.4	80.07	892.5	1177.8
84	12096	.714	315.2	5.13	.1949	286.2	811.7	80.13	891.9	1178.0
85	12240	5.782	316.0	5.07	0.1971	287.0	811.1	80.19	891.3	1178.3
86	11384	.850	316.8	5.02	.1993	287.9	810.4	80.25	890.7	1178.6
87	12528	.918	317.6	4.96	.2015	288.7	809.8	80.30	890.1	1178.9
88	12672	.986	318.4	4.91	.2036	289.5	809.2	80.35	889.5	1179.0
89	12816	6.054	319.2	4.86	.2058	290.4	808.5	80.40	888.9	1179.3
90	12960	6.122	320.0	4.81	0.2080	291.2	807.9	80.45	888.4	1179.5
91	13104	.190	320.8	4.76	.2102	292.0	807.3	80.50	887.8	1179.8
92	13248	.258	321.6	4.71	.2123	292.8	806.7	80.56	887.2	1180.0
93	13392	.327	322.4	4.66	.2145	293.6	806.1	80.61	886.7	1180.3
94	13536	.396	323.1	4.62	.2166	294.3	805.5	80.66	886.1	1180.5
95	13680	6.463	323.9	4.57	0.2188	295.1	804.9	80.71	885.6	1180.7
96	13824	.531	324.6	4.53	.2209	295.9	804.3	80.76	885.0	1180.9
97	13968	.599	325.4	4.48	.2231	296.7	803.7	80.81	884.5	1181.2
98	14112	.667	326.1	4.44	.2252	297.4	803.1	80.86	884.0	1181.4
99	14256	.735	326.8	4.40	.2274	298.2	802.5	80.91	883.4	1181.6

TABLE 253 (*continued*).

PROPERTIES OF STEAM.

British Measure.

Pressure in pounds per square inch.	Pressure in pounds per square foot.	Pressure in atmospheres.	Temp. in degrees Fahr.	Volume per pound in cubic feet.	Weight per cubic foot in pounds.	Heat of water per pound in B. T. U.	Internal latent heat per pound of steam in B. T. U.	External latent heat per pound of steam in B. T. U.	Total latent heat per pound of steam in B. T. U.	Total heat per pound of steam in B. T. U.
100	14400	6.803	327.6	4.356	0.2295	298.9	802.0	80.95	882.9	1181.8
101	14544	.871	328.3	.316	.2317	299.7	801.4	81.00	882.4	1182.1
102	14688	.939	329.0	.276	.2338	300.4	800.8	81.05	881.9	1182.3
103	14832	7.007	329.7	.237	.2360	301.1	800.3	81.10	881.4	1182.5
104	14976	.075	330.4	.199	.2381	301.9	799.7	81.14	880.8	1182.7
105	15120	7.143	331.1	4.161	0.2403	302.6	799.2	81.18	880.3	1182.9
106	15264	.211	331.8	.125	.2424	303.3	798.6	81.23	879.8	1183.1
107	15408	.279	332.5	.088	.2446	304.0	798.1	81.27	879.3	1183.4
108	15552	.347	333.2	.053	.2467	304.7	797.5	81.31	878.8	1183.6
109	15696	.415	333.8	.018	.2489	305.4	797.0	81.36	878.3	1183.8
110	15840	7.483	334.5	3.984	0.2510	306.1	796.5	81.41	877.9	1184.0
111	15984	.551	335.2	.950	.2531	306.8	795.9	81.45	877.4	1184.2
112	16128	.619	335.8	.917	.2553	307.5	795.4	81.50	876.9	1184.4
113	16272	.687	336.5	.885	.2574	308.2	794.9	81.54	876.4	1184.6
114	16416	.757	337.2	.853	.2596	308.8	794.4	81 58	875.9	1184.8
115	16560	7.823	337.8	3.821	0.2617	309.5	793.8	81.62	875.5	1185.0
116	16704	.891	338.5	.790	.2638	310.2	793.3	81.66	875.0	1185.2
117	16848	.959	339.1	.760	.2660	310.8	792.8	81.70	874.5	1185.4
118	16992	8.027	339.7	.730	.2681	311.5	792.3	81.74	874.1	1185.6
119	17136	.095	340.4	.700	.2702	312.1	791.8	81.78	873.6	1185.7
120	17280	8.163	341.0	3.671	0.2724	312.8	791.3	81.82	873.2	1185.9
121	17424	.231	341.6	.643	.2745	313.4	790.8	81.86	872.7	1186.1
122	17568	.299	342.2	.615	.2766	314.1	790.3	81.90	872.2	1186.3
123	17712	.367	342.8	.587	.2787	314.7	789.9	81.94	871.8	1186.5
124	17856	.435	343.5	.560	.2809	315.3	789.4	81.98	871.4	1186.7
125	18000	8.503	344.1	3.534	0.2830	316.0	788.9	82.02	870.9	1186.9
126	18144	.571	344.7	.507	.2851	316.6	788.4	82.06	870.5	1187.1
127	18288	.639	345.3	.481	.2872	317.2	787.9	82.09	870.0	1187.2
128	18432	.708	345.9	.456	.2893	317.8	787.5	82.13	869.6	1187.4
129	18576	.776	346.5	.431	.2915	318.4	787.0	82.17	869.2	1187.6
130	18720	8.844	347.1	3.406	0.2936	319.0	786.5	82.21	868.7	1187.8
131	18864	.912	347.6	.382	.2957	319.7	786.1	82.25	868.3	1188.0
132	19008	.980	348.2	.358	.2978	320.3	785.6	82.28	867.9	1188.1
133	19152	9.048	348.8	.334	.2999	320.9	785.1	82.32	867.5	1188.3
134	19296	.116	349.4	.310	.3021	321.5	784.7	82.35	867.0	1188.5
135	19440	9.184	349.9	3.287	0.3042	322.1	784.2	82.38	866.6	1188.7
136	19584	.252	350.5	.265	.3063	322.6	783.8	82.42	866.2	1188.8
137	19728	.320	351.1	.424	.3084	323.2	783.3	82.45	865.8	1189.0
138	19872	.388	351.6	.220	.3105	323.8	782.9	82.49	865.4	1189.2
139	20016	.456	352.2	.199	.3126	324.4	782.4	82.52	865.0	1189.4
140	20160	9.524	352.8	3.177	0.3147	325.0	782.0	82.56	864.6	1189.5
141	20304	.592	353.3	.156	.3168	325.5	781.6	82.59	864.2	1189.7
142	20448	.660	353.9	.135	.3190	326.1	781.1	82.63	863.8	1189.9
143	20592	.728	354.4	.115	.3211	326.7	780.7	82.66	863.4	1190.0
144	20736	.796	355.0	.094	.3232	327.2	780.3	82.69	863.0	1190.2
145	20880	9.864	355.5	3.074	0.3253	327.8	779.8	82.72	862.6	1190.4
146	21024	.932	356.0	.054	.3274	328.4	779.4	82.75	862.2	1190.5
147	21168	10.000	356.6	.035	.3295	328.9	779.0	82.79	861.8	1190.7
148	21312	.068	357.1	.016	.3316	329.5	778.6	82.82	861.4	1190.9
149	21456	.136	357.6	.997	.3337	330.0	778.1	82.86	861.0	1191.0

PROPERTIES OF STEAM.

British Measure.

Pressure in pounds per square inch.	Pressure in pounds per square foot.	Pressure in atmospheres.	Temp. in degrees Fahr.	Volume per pound in cubic feet.	Weight per cubic foot in pounds.	Heat of water per pound in B. T. U.	Internal latent heat per pound of steam in B. T. U.	External latent heat per pound of steam in B. T. U.	Total latent heat per pound of steam in B. T. U.	Total heat per pound of steam in B. T. U.
150	21600	10.204	358.2	2.978	0.3358	330.6	777.7	82.89	860.6	1191.2
151	21744	.272	358.7	.960	.3379	331.1	777.3	82.92	860.2	1191.3
152	21888	.340	359.2	.941	.3400	331.6	776.9	82.95	859.9	1191.5
153	22032	.408	359.7	.923	.3421	332.2	776.5	82.98	859.5	1191.7
154	22176	.476	360.2	.906	.3442	332.7	776.1	83.01	859.1	1191.8
155	22320	10.544	360.7	2.888	0.3462	333.2	775.7	83.04	858.7	1192.0
156	22464	.612	361.3	.871	.3483	333.8	775.3	83.07	858.3	1192.1
157	22608	.680	361.8	.854	.3504	334.3	774.9	83.10	858.0	1192.3
158	22752	.748	362.3	.837	.3525	334.8	774.5	83.13	857.6	1192.4
159	22896	.816	362.8	.820	.3546	335.3	774.1	83.16	857.2	1192.6
160	23040	10.884	363.3	2.803	0.3567	335.9	773.7	83.19	856.9	1192.7
161	23184	.952	363.8	.787	.3588	336.4	773.3	83.22	856.5	1192.9
162	23328	11.020	364.3	.771	.3609	336.9	772.9	83.25	856.1	1193.0
163	23472	.088	364.8	.755	.3630	337.4	772.5	83.28	855.8	1193.2
164	23616	.157	365.3	.739	.3650	337.9	772.1	83.31	855.4	1193.3
165	23760	11.225	365.7	2.724	0.3671	338.4	771.7	83.34	855.1	1193.5
166	23904	.293	366.2	.708	.3692	338.9	771.3	83.37	854.7	1193.6
167	24048	.361	366.7	.693	.3713	339.4	771.0	83.39	854.3	1193.8
168	24192	.429	367.2	.678	.3734	339.9	770.6	83.42	854.0	1193.9
169	24336	.497	367.7	.663	.3754	340.4	770.2	83.45	853.6	1194.1
170	24480	11.565	368.2	2.649	0.3775	340.9	769.8	83.48	853.3	1194.2
171	24624	.633	368.6	.634	.3796	341.4	769.4	83.51	852.9	1194.4
172	24768	.701	369.1	.620	.3817	341.9	769.1	83.54	852.6	1194.5
173	24912	.769	369.6	.606	.3838	342.4	768.7	83.56	852.2	1194.7
174	25056	.837	370.0	.592	.3858	342.9	768.3	83.59	851.9	1194.8
175	25200	11.905	370.5	2.578	0.3879	343.4	767.9	83.62	851.6	1194.9
176	25344	.973	371.0	.564	.3900	343.9	767.6	83.64	851.2	1195.1
177	25488	12.041	371.4	.550	.3921	344.3	767.2	83.67	850.9	1195.2
178	25632	.109	371.9	.537	.3942	344.8	766.8	83.70	850.5	1195.4
179	25776	.177	372.4	524	.3962	345.3	766.5	83.73	850.2	1195.5
180	25920	12.245	372.8	2.510	0.3983	345.8	766.1	83.75	849.9	1195.6
181	26064	.313	373.3	.497	.4004	346.3	765.8	83.77	849.5	1195.8
182	26208	.381	373.7	.485	.4025	346.7	765.4	83.80	849.2	1195.9
183	26352	.449	374.2	.472	.4046	347.2	765.0	83.83	848.9	1196.1
184	26496	.517	374.6	.459	.4066	347.7	764.7	83.86	848.5	1196.2
185	26640	12.585	375.1	2.447	0.4087	348.1	764.3	83.88	848.2	1196.3
186	26784	.653	375.5	.434	.4108	348.6	764.0	83.90	847.9	1196.5
187	26928	.721	376.0	.422	.4129	349.1	763.6	83.92	847.5	1196.6
188	27072	.789	376.4	.410	.4150	349.5	763.3	83.95	847.2	1196.7
189	27216	.857	376.8	.398	.4170	350.0	762.9	83.97	846.9	1196.9
190	27360	12.925	377.3	2.386	0.4191	350.4	762.6	83.99	846.6	1197.0
191	27504	.993	377.7	.374	.4212	350.9	762.2	84.02	846.3	1197.1
192	27648	13.061	378.2	.362	.4233	351.3	761.9	84.04	845.9	1197.3
193	27792	.129	378.6	.351	.4254	351.8	761.6	84.06	845.6	1197.4
194	27936	.197	379.0	.339	.4275	352.2	761.2	84.08	845.3	1197.5
195	28080	13.265	379.4	2.328	0.4296	352.7	760.9	84.10	845.0	1197.7
196	28224	.333	379.9	.317	.4316	353.1	760.5	84.13	844.7	1197.8
197	28368	.401	380.3	.306	.4337	353.6	760.2	84.16	844.4	1197.9
198	28512	.469	380.7	.295	.4358	354.0	759.9	84.19	844.0	1198.1
199	28656	.537	381.1	.284	.4379	354.4	759.5	84.21	843.7	1198.2

TABLE 253 (*continued*).

PROPERTIES OF STEAM.

British Measure.

Pressure in pounds per square inch.	Pressure in pounds per square foot.	Pressure in atmospheres.	Temp. in degrees Fahr.	Volume per pound in cubic feet.	Weight per cubic foot in pounds.	Heat of water per pound in B. T. U.	Internal latent heat per pound of steam in B. T. U.	External latent heat per pound of steam in B. T. U.	Total latent heat per pound of steam in B. T. U.	Total heat per pound of steam in B. T. U.
200	28800	13.605	381.6	2.273	0.4399	354.9	759.2	84.23	843.4	1198.3
201	28944	13.673	382.0	.262	.4420	355.3	758.9	84.26	843.1	1198.4
202	29088	13.742	382.4	.252	.4441	355.8	758.5	84.28	842.8	1198.6
203	29232	13.810	382.8	.241	.4461	356.2	758.2	84.30	842.5	1198.7
204	29376	13.878	383.2	.231	.4482	356.6	757.9	84.33	842.2	1198.8
205	29520	13.946	383.7	2.221	0.4503	357.1	757.5	84.35	841.9	1199.0
206	29664	14.014	384.1	.211	.4523	357.5	757.2	84.37	841.6	1199.1
207	29808	14.082	384.5	.201	.4544	357.9	756.9	84.40	841.3	1199.2
208	29952	14.150	384.9	.191	.4564	358.3	756.6	84.42	841.0	1199.3
209	30096	14.218	385.3	.181	.4585	358.8	756.2	84.44	840.7	1199.4
210	30240	14.386	385.7	2.171	0.4605	359.2	755.9	84.46	840.4	1199.6
211	30384	14.454	386.1	.162	.4626	359.6	755.6	84.48	840.1	1199.7
212	30528	14.522	386.5	.152	.4646	360.0	755.3	84.51	839.8	1199.8
213	30672	14.590	386.9	.143	.4666	360.4	755.0	84.53	839.5	1199.9
214	30816	14.658	387.3	.134	.4687	360.9	754.7	84.55	839.2	1200.1
215	30960	14.726	387.7	2.124	0.4707	361.3	754.3	84.57	838.9	1200.2
216	31104	14.794	388.1	.115	.4727	361.7	754.0	84.60	838.6	1200.3
217	31248	14.862	388.5	.106	.4748	362.1	753.7	84.62	838.3	1200.4
218	31392	14.930	388.9	.097	.4768	362.5	753.4	84.64	838.0	1200.5
219	31536	14.998	389.3	.088	.4788	362.9	753.1	84.66	837.7	1200.7

TABLE 254.

RATIO OF THE ELECTROSTATIC TO THE ELECTROMAGNETIC UNIT OF ELECTRICITY = *V*.

Date.	*V* Cm. per sec.	Mean.	Determined by	Reference.
1856		3.11×10^{10}	R. Kohlrausch and W. Weber.	Pogg. Ann. 99; 1856.
1868	$2.75–2.92 \times 10^{10}$	2.84	Maxwell.	Phil. Trans.; 1868.
1869	2.71–2.88	2.81	Thomson and King.	B. A. Report; 1869.
1874	2.86–3.00	2.90	McKichan.	Phil. Mag. 47; 1874.
1879	2.950–3.018	2.981	Rowland.	Phil. Mag. 28; 1889.
1879	–	2.96	Ayrton and Perry.	Phil. Mag. 7; 1879.
1879	–	2.967	Hockin.	B. A. Report; 1879.
1880	–	2.955	Shida.	Phil. Mag. 10; 1880.
1881	2.98–3.00	2.99	Stoletow.	Jour. de Phys.; 1881.
1882	–	2.87	Exner.	Wien. Ber.; 1882.
1883	–	2.963	J. J. Thomson.	Phil. Trans.; 1883.
1884	3.001–3.029	3.019	Klemenčič.	Wien. Ber. 83, 89, 93; 1881–6.
"	3.016–3.031			
1886	–	3.015	Colley.	Wied. Ann. 28; 1886.
1886–8	2.999–3.009			
"	3.003–3.008	3.009	Himstedt.	Wied. Ann. 29, 33, 35; 1887–8.
"	3.005–3.015			
1888	–	2.92	Thomson, Ayrton and Perry.	Electr. Rev. 23; 1888–9.
1889	2.995–3.010	3.000	Rosa.	Phil. Mag. 28; 1889.
1890	–	2.996	J. J. Thomson and Searle.	Phil. Trans.; 1890.
1891	–	3.009	Pellat.	Jour. de Phys. 10; 1891.
1892	2.990–2.995	2.991	Abraham.	Ann. Chim. et Phys. 27; 1829.
1896	–	3.001	Hurmuzescu.	Ann. Chim. et Phys. 10; 1897.
1898	–	2.9973	Perot and Fabry.	Ann. Chim. et Phys. 13; 1898.
1898	–	3.026	Webster.	Phys. Rev. 6; 1898.
1899	–	3.009	Lodge and Glazebrook.	Cam. Phil. Soc. 18; 1899.
1904–7	2.99706–2.99741	2.9971	Rosa and Dorsey.	Bull. Bur. Standards 3; 1907.

The last of the above determinations is the result of an extended series of measurements upon various forms of condensers, and is believed to be correct within 1/100 per cent. This, however, assumes that the International Ohm is 10^9 c.g.s. units. The value of *V* is therefore subject to one-half the error of the International Ohm.

DIELECTRIC STRENGTH.

TABLE 255. — Steady Potential Difference in Volts required to produce a Spark in Air with Ball Electrodes.

Spark length. cm.	*R* = 0. Points.	*R* = 0.25 cm.	*R* = 0.5 cm.	*R* = 1 cm.	*R* = 2 cm.	*R* = 3 cm.	*R* = ∞. Plates.
0.02	–	–	1560	1530			
0.04	–	–	2460	2430	2340		
0.06	–	–	3300	3240	3060		
0.08	–	–	4050	3990	3810		
0.1	3720	5010	4740	4560	4560	4500	4350
0.2	4680	8610	8490	8490	8370	7770	7590
0.3	5310	11140	11460	11340	11190	10560	10650
0.4	5970	14040	14310	14340	14250	13140	13560
0.5	6300	15990	16950	17220	16650	16470	16320
0.6	6840	17130	19740	20070	20070	19380	19110
0.8	8070	18960	23790	24780	25830	26220	24960
1.0	8670	20670	26190	27810	29850	32760	30840
1.5	9960	22770	29970	37260			
2.0	10140	24570	33060	45480			
3.0	11250	28380					
4.0	12210	29580					
5.0	13050						

Based on the results of Baille, Bichat-Bloodot, Freyburg, Liebig, Macfarlane, Orgler, Paschen, Quincke, de la Rue, Wolff. For spark lengths from 1 to 200 wave-lengths of sodium light, see Earhart, Phys. Rev. 15, p. 163; Hobbs, Phil. Mag. 10, p. 607, 1905.

TABLE 256. — Alternating Current Potentials required to produce a Spark in Air with various Ball Electrodes.

The potentials given are the maxima of the alternating waves used. Frequency, 33 cycles per second.

Spark length. cm.	*R* = 1 cm.	*R* = 1.92	*R* = 5	*R* = 7.5	*R* = 10	*R* = 15
0.08	3770					
.10	4400	4380	4330	4290	4245	4230
.15	5990	5940	5830	5790	5800	5780
.20	7510	7440	7340	7250	7320	7330
.25	9045	8970	8850	8710	8760	8760
0.30	10480	10400	10270	10130	10180	10150
.35	11980	11890	11670	11570	11610	11590
.40	13360	13300	13100	12930	12980	12970
.45	14770	14700	14400	14290	14330	14320
.50	16140	16070	15890	15640	15690	15690
0.6	18700	18730	18550	18300	18350	18400
.7	21350	21380	21140	20980	20990	21000
.8	23820	24070	23740	23490	23540	23550
0.9	26190	26640	26400	26130	26110	26090
1.0	28380	29170	28950	28770	28680	28610
1.2	32400	34100	33790	33660	33640	33620
1.4	35850	38850	38850	38580	38620	38580
1.6	38750	43400	43570	43250	43520	
1.8	40900	–	48300	47900		
2.0	42950	–	–	52400		

Based upon the results of Kawalski, Phil. Mag. 18, 1909.

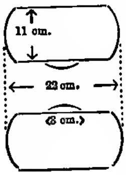
TABLES 257, 258.

DIELECTRIC STRENGTH.

TABLE 257. — Potential Necessary to produce a Spark in Air between more widely Separated Electrodes.

Spark length, cm.	Dull points. Alternating current.	Steady potentials.				Spark length, cm.	Dull points. Alternating current.	Steady potentials.	
		Ball electrodes.		Cup electrodes.				Ball electrodes.	
				Projection.					
		R=1 cm.	R=2.5 cm.	4.5 mm.	1.5 mm.			R=1 cm.	R=2.5 cm.
0.3	–	–	–	–	11280	6.0	61000		86830
0.5	–	17610	17620	–	17420	7.0		52000	–
0.7	–	–	23050	–	22950	8.0	67000	52400	90200
1.0	12000	30240	31390	31400	31260	10.0	73000	74300	91930
1.2	–	33800	36810	–	36700	12.0	82600	–	93300
1.5	–	37930	44310	–	44510	14.0	92000	–	94400
2.0	29200	42320	56000	56500	56530	15.0	–	–	94700
2.5	–	45000	65180	–	68720	16.0	101000	–	101000
3.0	40000	46710	71200	80400	81140	20.0	119000		
3.5	–	–	75300	–	92400	25.0	140600		
4.0	48500	49100	78600	101700	103800	30.0	165700		
4.5	–	–	81540	–	114600	35.0	190900		
5.0	56500	50310	83800	–	126500				
5.5	–	–	–	–	135700				

This table for longer spark lengths contains the results of Voege, Ann. der Phys. 14, 1904, using alternating current and "dull point" electrodes, and the results with steady potential found in the recent very careful work of C. Müller, Ann. d. Phys. 29, 1909.



The specially constructed electrodes for the columns headed "cup electrodes" had the form of a projecting knob 3 cm. in diameter and having a height of 4.5 mm. and 1.5 mm. respectively, attached to the plane face of the electrodes. These electrodes give a very satisfactory linear relation between the spark lengths and the voltage throughout the range studied.

TABLE 258. — Effect of the Pressure of the Gas on the Dielectric Strength.

Voltages are given for different spark lengths *l*.

Pressure. cm. Hg.	l=0.04	l=0.06	l=0.08	l=0.10	l=0.20	l=0 30	l=0.40	l=0.50
2	–	–	–	–	744	939	1110	1266
4	–	483	567	648	1015	1350	1645	1915
6	–	582	690	795	1290	1740	2140	2505
10	–	771	933	1090	1840	2450	3015	3580
15	–	1060	1280	1490	2460	3300	4080	4850
25	1110	1420	1725	2040	3500	4800	6000	7120
35	1375	1820	2220	2615	4505	6270	7870	9340
45	1640	2150	2660	3120	5475	7650	9620	11420
55	1820	2420	3025	3610	6375	8950	11290	13455
65	2040	2720	3400	4060	7245	10210	12950	15470
75	2255	3035	3805	4565	8200	11570	14650	17450

This table is based upon the results of Orgler, 1899. See this paper for work on other gases (or Landolt-Börnstein-Meyerhoffer).

For long spark lengths in various gases see Voege, Electrotechn. Z. 28, 1907. For dielectric strength of air and CO_2 in cylindrical air condensers, see Wien, Ann. d. Phys. 29, 1909.

DIELECTRIC STRENGTH.

TABLE 259. — Dielectric Strength of Materials.

Potential necessary for puncture expressed in kilovolts per centimetre thickness of the dielectric.

Substance.	Kilovolts per cm.	Substance.	Kilovolts per cm.	Substance.	Kilovolts per cm.
Ebonite	300–1100	Oils: Thickness.		Papers:	
Empire cloth . .	80–300	Castor 0.2 mm.	190	Beeswaxed . .	770
" paper . .	450	" 1.0 "	130	Blotting . . .	150
Fibre	20	Cottonseed	70	Manilla . . .	25
Fuller board . .	200–300	Lard 0.2 "	140	Paraffined . .	500
Glass	300–1500	" 1.0 "	40	Varnished . .	100–250
Granite (fused) .	90	Linseed, raw 0.2 "	185	Paraffine:	
Guttapercha. . .	80–200	" " 1.0 "	90	Melted . . .	75
Impregnated jute .	20	" boiled 0.2 "	190	Melt point.	
Leatheroid . . .	30–60	" " 1.0 "	80	Solid 43°	350
Linen, varnished .	100–200	Lubricating	50	" 47°	400
Liquid air . . .	40–90	Neatsfoot 0.2 "	200	" 52°	230
Mica: Thickness.		" 1.0 "	90	" 70°	450
Madras 0.1 mm.	1600	Olive 0.2 "	170	Presspaper . . .	45–75
" 1.0 "	300	" 1.0 "	75	Rubber	160–500
Bengal 0.1 "	2200	Paraffin 0.2 "	215	Vaseline. . . .	90–130
" 1.0 "	700	" 1.0 "	160	Thickness.	
Canada 0.1 "	1500	Sperm, mineral 0.2 "	180	Xylol 0.2 mm.	140
" 1.0 "	500	" " 1.0 "	85	" 1.0 "	80
South America .	1500	" natural 0.2 "	195		
Micanite . . .	4000	" " 1.0 "	90		
		Turpentine 0.2 "	160		
		" 1.0 "	110		

TABLE 260. — Potentials in Volts to Produce a Spark in Kerosene.

Spark length. mm.	Electrodes Balls of Diam. *d*.			
	0.5 cm.	1 cm.	2 cm.	3 cm.
0.1	3800	3400	2750	2200
.2	7500	6450	4800	3500
.3	10250	9450	7450	4600
.4	11750	10750	9100	5600
.5	13050	12400	11000	6900
.6	14000	13550	12250	8250
.8	15500	15100	13850	10450
1.0	16750	16400	15250	12350

Determinations of the dielectric strength of the same substance by different observers do not agree well. For a discussion of the sources of error see Mośćicki, Electrotechn. Z. 25, 1904.

For more detailed information on the dependence of the sparking distance in oils as a function of the nature of the electrodes, see Edmondson, Phys. Review 6, 1898.

TABLE 261.

ABSOLUTE MEASUREMENTS OF CURRENT AND OF THE ELECTROMOTIVE FORCE OF STANDARD CELLS.

Date.	Observer.	Method.	Electromotive Force of		Electrochemical Equivalent found with Voltameter of	
			Clark Cell at 15°.	Weston Cell at 20°.	Rayleigh Form.	Porous Cup Form.
			volts.	volts.	mg.	mg.
1884	F. and W. Kohlrausch	Tangent galvanometer. Filter paper voltameter	–	–	1.1183	
1884	Rayleigh & Sidgwick.	Current balance . . . Filter paper voltameter	1.4345	–	1.1179	
1890	Potier and Pellat . .	Current balance . . . Filter paper voltameter	–	–	1.1192	
1896	Kahle	Current balance . . .	1.4328	1.0186	1.1182	
1898	Patterson and Guthe.	Electrodynamometer . Silver oxide voltameter	–	–	–	1.1192
1899	Carhart and Guthe . .	Electrodynamometer .	1.4333			
1903	Pellat and Leduc . .	Current balance . . . Leduc voltameter . .	–	–	1.1195	
1904	Van Dijk and Kunst.	Tangent galvanometer. Filter paper voltameter	–	–	1.1182	
1906	Guthe	Electrodynamometer .	1.4330	1.0185	–	1.1177
1907	Ayrton, Mather and Smith	Current balance . . .	1.4323	1.01819		
1907	Smith and Lowry . .	Filter paper voltameter	–	–	1.11827	
1908	Janet, Laporte and Jouaust	Filter paper voltameter Current balance . . .	–	1.0187	1.1182	
1908	Pellat	Current balance . . .	–	1.0184		
1908	Guillet	Current balance . . .	–	1.0182		

The most probable value of the Weston cell at 20° is 1.0182 volts, assuming the International ohm to be 10^9 c. g. s. units and the volt to be 10^8 c. g. s. units. The corresponding value of the Clark cell, as prepared at present, at 15°, is 1.4324 volts.

The legal values of the Weston cell, however, are different in different countries, as follows:

United States (Bureau of Standards)	1.019125* v. at 20°
Germany (Physikalisch-Technische Reichsanstalt)	1.0186 volts at 20°
England (National Physical Laboratory)	1.0184 volts at 20°

The value of the Weston standard cell, used in the United States, is based upon the value adopted by the Chicago Electrical Congress (1893) for the Clark cell. The value used by Germany was adopted in 1896, and is based on Kahle's work at the Reichsanstalt. The value used in England was adopted January 1, 1909, and is based on the recommendation of the London Electrical Conference of 1908. It is expected that a new value will soon be agreed upon by the International Committee on Electrical Units and Standards, which will be adopted generally in all countries.

The value of the electrochemical equivalent of silver is different when filter paper (Rayleigh form), silk, or other textile is used to separate the anode from the cathode from what it is when a porous cup is employed. The value found is also affected by the addition of silver oxide to the silver nitrate solution. The legal value in all countries is 1.118 mg. of silver per coulomb, and this is nearly the value found when using a porous cup voltameter, and the best determinations of the current that have been made by absolute current balances. Some corrections have been made to the figures given in the above table for the excess due to filter paper, but such corrections are very uncertain.

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* Based on 1.0189 at 25° C.

TABLE 262.

COMPOSITION AND ELECTROMOTIVE FORCE OF VOLTAIC CELLS.

The electromotive forces given in this table approximately represent what may be expected from a cell in good working order, but with the exception of the standard cells all of them are subject to considerable variation.

(a) DOUBLE FLUID CELLS.

Name of cell.	Negative pole.	Solution.	Positive pole.	Solution.	E.M.F. in volts.
Bunsen . .	Amalgamated zinc	1 part H_2SO_4 to 12 parts H_2O .	Carbon	Fuming H_2NO_3 .	1.94
" . .	" "	"	"	HNO_3, density 1.38	1.86
Chromate .	" "	12 parts $K_2Cr_2O_7$ to 25 parts of H_2SO_4 and 100 parts H_2O . .	"	1 part H_2SO_4 to 12 parts H_2O .	2.00
" .	" "	1 part H_2SO_4 to 12 parts H_2O .	"	12 parts $K_2Cr_2O_7$ to 100 parts H_2O	2.03
Daniell* .	" "	1 part H_2SO_4 to 4 parts H_2O .	Copper	Saturated solution of $CuSO_4+5H_2O$	1.06
" .	" "	1 part H_2SO_4 to 12 parts H_2O .	"	"	1.09
" .	" "	5% solution of $ZnSO_4+6H_2O$	"	"	1.08
" .	" "	1 part NaCl to 4 parts H_2O .	"	"	1.05
Grove . .	" "	1 part H_2SO_4 to 12 parts H_2O .	Platinum	Fuming HNO_3 . .	1.93
" . .	" "	Solution of $ZnSO_4$	"	HNO_3, density 1.33	1.66
" . .	" "	H_2SO_4 solution, density 1.136 .	"	Concentrated HNO_3	1.93
" . .	" "	H_2SO_4 solution, density 1.136 .	"	HNO_3, density 1.33	1.79
" . .	" "	H_2SO_4 solution, density 1.06 .	"	"	1.71
" . .	" "	H_2SO_4 solution, density 1.14 .	"	HNO_3, density 1.19	1.66
" . .	" "	H_2SO_4 solution, density 1.06 .	"	" " "	1.61
" . .	" "	NaCl solution . .	"	" density 1.33	1.88
Marié Davy	" "	1 part H_2SO_4 to 12 parts H_2O	Carbon	Paste of protosulphate of mercury and water . . .	1.50
Partz . .	" "	Solution of $MgSO_4$	"	Solution of $K_2Cr_2O_7$	2.06

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* The Minotto or Sawdust, the Meidinger, the Callaud, and the Lockwood cells are modifications of the Daniell, and hence have about the same electromotive force.

TABLE 262 (*continued*).

COMPOSITION AND ELECTROMOTIVE FORCE OF VOLTAIC CELLS.

Name of cell.	Negative pole.	Solution.	Positive pole.	E. M. F. in volts.
(b) SINGLE FLUID CELLS.				
Leclanche . . .	Amal. zinc	Solution of sal-ammoniac	Carbon. Depolarizer: manganese peroxide with powdered carbon	1.46
Chaperon . . .	" "	Solution of caustic potash	Copper. Depolarizer: CuO . . .	0.98
Edison-Lelande .	" "	"	"	0.70
Chloride of silver	Zinc . .	23 % solution of sal-ammoniac	Silver. Depolarizer: silver chl'ride	1.02
Law	" . .	15 % " "	Carbon	1.37
Dry cell (Gassner)	" . .	1 pt. ZnO, 1 pt. NH_4Cl, 3 pts. plaster of paris, 2 pts. $ZnCl_2$, and water to make a paste . .	"	1.3
Poggendorff . .	Amal. zinc	Solution of chromate of potash	"	1.08
" . . .	" "	12 parts $K_2Cr_2O_7$ + 25 parts H_2SO_4 + 100 parts H_2O . .	"	2.01
J. Regnault . . .	" "	1 part H_2SO_4 + 12 parts H_2O + 1 part $CaSO_4$ . .	Cadmium . . .	0.34
Volta couple . .	Zinc . .	H_2O	Copper	0.98
(c) STANDARD CELLS.				
Weston normal .	Cadmi'm am'lgam	Saturated solution of $CdSO_4$	Mercury. Depolarizer: paste of Hg_2SO_4 and $CdSO_4$	1.0191 at 20° C
Clark standard .	Zinc am'lgam	Saturated solution of $ZnSO_4$	Mercury. Depolarizer: paste of Hg_2SO_4 and $ZnSO_4$	1.434* at 15°C
(d) SECONDARY CELLS.				
Lead accumulator	Lead . .	H_2SO_4 solution of density 1.1 . . .	PbO_2	2.2†
Regnier (1) . . .	Copper .	$CuSO_4 + H_2SO_4$ . .	"	1.68 to 0.85, average 1.3.
" (2) . . .	Amal. zinc	$ZnSO_4$ solution . . .	" in H_2SO_4 .	2.36
Main	Amal. zinc	H_2SO_4 density ab't 1.1	"	2.50
Edison	Iron . .	KOH 20 % solution .	A nickel oxide .	1.1, mean of full discharge.

* E. M. F. hitherto used at Bureau of Standards. See p. 251. The temperature formula is $E_t = E_{20} - 0.0000406 (t-20) - 0.00000095 (t-20)^2 + 0.00000001 (t-20)^3$. The value given is that adopted by the Chicago International Electrical Congress in 1893. The temperature formula is $E_t = E_{15} - 0.00119 (t-15) - 0.000007 (t-15)^2$.

† F. Streiutz gives the following value of the temperature variation $\frac{dE}{dt}$ at different stages of charge:

E. M. F.	1.9223	1.9828	2.0031	2.0084	2.0105	2.0779	2.2070
$dE/dt \times 10^6$	140	228	335	285	255	130	73

Dolezalek gives the following relation between E. M. F. and acid concentration:

Per cent H_2SO_4	64.5	52.2	35.3	21.4	5.2
E.M.F., 0° C	2.37	2.25	2.10	2.00	1.89

TABLE 263.

CONTACT DIFFERENCE OF

Solids with Liquids and

Temperature of substances

	Carbon.	Copper.	Iron.	Lead.	Platinum.	Tin.	Zinc.
Distilled water	.01 to .17	.269 to .100	.148	.171	.285 to .345	.177	—.105 to +.156
Alum solution: saturated at 16°.5 C.	-	—.127	—.653	—.139	.246	—.225	—.536
Copper sulphate solution: sp. gr. 1.087 at 16°.6 C.	-	.103	-	-	-	-	-
Copper sulphate solution: saturated at 15° C. . .	-	.070	-	-	-	-	-
Sea salt solution: sp. gr. 1.18 at 20°.5 C. . . .	-	—.475	—.605	-	—.856	—.334	—.565
Sal-ammoniac solution: saturated at 15°.5 C. .	-	—.396	—.652	—.189	.059	—.364	—.637
Zinc sulphate solution: sp. gr. 1.125 at 16°.9 C. . .	-	-	-	-	-	-	—.238
Zinc sulphate solution: saturated at 15°.3 C. .	-	-	-	-	-	-	—.430
One part distilled water + 3 parts saturated zinc sulphate solution . . .	-	-	-	-	-	-	—.444
Strong sulphuric acid in distilled water:							
1 to 20 by weight . . .	-	-	-	-	-	-	—.344
1 to 10 by volume . . .	about —.035	-	-	-	-	-	-
1 to 5 by weight	-	-	-	-	-	-	-
5 to 1 by weight	.01 to 3.0	-	-	—.120	-	—.25	-
Concentrated sulphuric acid	.55 to .85	1.113	-	.72 to 1.252	1.3 to 1.6	-	-
Concentrated nitric acid .	-	-	-	-	.672	-	-
Mercurous sulphate paste .	-	-	-	-	-	-	-
Distilled water containing trace of sulphuric acid	-	-	-	-	-	-	—.241

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* Everett's "Units and Physical Constants:" Table of

POTENTIAL IN VOLTS.

Liquids with Liquids in Air.*

during experiment about 16° C.

	Amalgamated zinc.	Brass.	Mercury.	Distilled water.	Alum solution: saturated at 16°.5 C.	Copper sulphate solution: saturated at 15° C.	Zinc sulphate solution: sp. gr. 1.25 at 16°.9 C.	Zinc sulphate solution: saturated at 15°.3 C.	One part distilled water + 3 pts. zinc sulphate.	Strong nitric acid.
Distilled water	.100	.231	-	-	-	—.043	-	.164	-	-
Alum solution: saturated at 16°.5 C.	-	—.014	-	-	-	-	-	-	-	-
Copper sulphate solution: sp. gr. 1.087 at 16°.6 C.	-		-	-	-	-	.090	-	-	-
Copper sulphate solution: saturated at 15° C.	-	-	-	—.043	-	-	-	.095	.102	-
Sea salt solution: sp. gr. 1.18 at 20°.5 C.	-	—.435	-	-	-	-	-	-	-	-
Sal-ammoniac solution: saturated at 15°.5 C.	-	—.348	-	-	-	-	-	-	-	-
Zinc sulphate solution: sp. gr. 1.125 at 16°.9 C.	-	-	-	-	-	-	-	-	-	-
Zinc sulphate solution: saturated at 15°.3 C.	—.284	-	-	—.200	-	—.095	-	-	-	-
One part distilled water + 3 parts saturated zinc sulphate solution	-	-	-	-	-	—.102	-	-	-	-
Strong sulphuric acid in distilled water:										
1 to 20 by weight	-	-	-	-	-	-	-	-	-	-
1 to 10 by volume	—.358	-	-	-	-	-	-	-	-	-
1 to 5 by weight	.429	-	-	-	-	-	-	-	-	-
5 to 1 by weight	-	—.016	-	-	-	-	-	-	-	-
Concentrated sulphuric acid	.848	-	-	1.298	1.456	1.269	-	1.699	-	-
Concentrated nitric acid			-	-	-	-	-	-	-	-
Mercurous sulphate paste	-	-	.475	-	-	-	-	-	-	-
Distilled water containing trace of sulphuric acid	-	-	-	-	-	-	-	-	-	.078

Ayrton and Perry's results, prepared by Ayrton.

TABLE 264.

CONTACT DIFFERENCE OF POTENTIAL IN VOLTS.

Solids with Solids in Air.*

The following results are the "Volta differences of potential," as measured by an electrometer. They represent the difference of the potentials of the air near each of two metals placed in contact. This should not be confused with the junction electromotive force at the junction of two metals in metallic contact, which has a definite value, proportional to the coefficient of Peltier effect. The Volta difference of potential has been found to vary with the condition of the metallic surfaces and with the nature of the surrounding gas. No great reliance, therefore, can be placed on the tabulated values.

The temperature of the substances during the experiment was about 18° C.

	Carbon.	Copper.	Iron.	Lead.	Platinum.	Tin.	Zinc.	Zinc amalgam.	Brass.
Carbon . . .	0	.370	.485	.858	.113	.795	1.096†	1.208†	.414†
Copper . . .	—.370	0	.146	.542	—.238	.456	.750	.894	.087
Iron	—.485†	—.146	0	.401†	—.369	.313†	.600†	.744†	—.064
Lead . . .	—.858	—.542	—.401	0	—.771	—.099	.210	.357†	—.472
Platinum . .	—.113†	.238	.369	.771	0	.690	.981	1.125†	.287
Tin	—.795†	—.458	—.313	.099	—.690	0	.281	.463	—.372
Zinc	—1.096†	—.750	—.600	—.216	—.981	.281	0	.144	—.679
" amalgam	—1.208†	—.894	—.744	—.357†	—1.125†	—.463	—.144	0	—.822
Brass . . .	—.414	—.087	.064	.472	—.287	.372	.679	.822	0

The numbers not marked were obtained by direct experiment, those marked with a dagger by calculation, on the assumption that in a compound circuit of metals, all at the same temperature, there is no electromotive force.

The numbers in the same vertical column are the differences of potential in volts between the substance named at the top of the column and the substance named on the same line in the first column, when the two substances are in contact.

The metals used were those ordinarily obtained in commerce.

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* Everett's "Units and Physical Constants." The table is from Ayrton and Perry's experiments, and was prepared by Ayrton.

DIFFERENCE OF POTENTIAL BETWEEN METALS IN SOLUTIONS OF SALTS.

The following numbers are given by G. Magnanini * for the difference of potential in hundredths of a volt between zinc in a normal solution of sulphuric acid and the metals named at the head of the different columns when placed in the solution named in the first column. The solutions were contained in a U-tube, and the sign of the difference of potential is such that the current will flow from the more positive to the less positive through the external circuit.

Strength of the solution in gramme molecules per litre.		Zinc.†	Cadmium.†	Lead.	Tin.	Copper.	Silver.
No. of molecules.	Salt.	Difference of potential in centivolts.					
0.5	H_2SO_4	0.0	36.6	51.3	51.3	100.7	121.3
1.0	$NaOH$	—32.1	19.5	31.8	0.2	80.2	95.8
1.0	KOH	—42.5	15.5	32.0	—1.2	77.0	104.0
0.5	Na_2SO_4	1.4	35.6	50.8	51.4	101.3	120.9
1.0	$Na_2S_2O_8$	—5.9	24.1	45.3	45.7	38.8	64.8
1.0	KNO_3	11.8‡	31.9	42.6	31.1	81.2	105.7
1.0	$NaNO_3$	11.5	32.3	51.0	40.9	95.7	114.8
0.5	K_2CrO_4	23.9‡	42.8	41.2	40.9	94.6	121.0
0.5	$K_2Cr_2O_7$	72.8	61.1	78.4	68.1	123.6	132.4
0.5	K_2SO_4	1.8	34.7	51.0	40.9	95.7	114.8
0.5	$(NH_4)_2SO_4$	—0.5	37.1	53.2	57.6‡	101.5	125.7
0.25	$K_4FeC_6N_6$	—6.1	33.6	50.7	41.2	—‡	87.8
0.167	$K_6Fe_2(CN)_2$	41.0§	80.8	81.2	130.9	110.7	124.9
1.0	$KCNS$	—1.2	32.5	52.8	52.7	52.5	72.5
1.0	$NaNO_3$	4.5	35.2	50.2	49.0	103.6	104.6?
0.5	$SrNO_3$	14.8	38.3	50.6	48.7	103.0	119.3
0.125	$Ba(NO_3)_2$	21.9	39.3	51.7	52.8	109.6	121.5
1.0	KNO_3	—‡	35.6	47.5	49.9	104.8	115.0
0.2	$KClO_3$	15–10‡	39.9	53.8	57.7	105.3	120.9
0.167	$KBrO_3$	13–20‡	40.7	51.3	50.9	111.3	120.8
1.0	NH_4Cl	2.9	32.4	51.3	50.9	81.2	101.7
1.0	KF	2.8	22.5	41.1	50.8	61.3	61.5
1.0	$NaCl$	—	31.9	51.2	50.3	80.9	101.3
1.0	KBr	2.3	31.7	47.2	52.5	73.6	82.4
1.0	KCl	—	32.1	51.6	52.6	81.6	107.6
0.5	Na_2SO_3	—8.2	28.7	41.0	31.0	68.7	103.7
– ‖	$NaOBr$	18.4	41.6	73.1	70.6 ‡	89.9	99.7
1.0	$C_4H_6O_6$	5.5	39.7	61.3	54.4§	104.6	123.4
0.5	$C_4H_6O_8$	4.1	41.3	61.6	57.6	110.9	125.7
0.5	$C_4H_4KNaO_6$	—7.9	31.5	51.5	42–47	100.8	119.7

* "Rend. della R. Acc. di Roma," 1890.

† Amalgamated.

‡ Not constant.

§ After some time.

‖ A quantity of bromine was used corresponding to NaOH = 1.

TABLE 266.

THERMOELECTRIC POWER.

The thermoelectric power of a circuit of two metals is the electromotive force produced by one degree C. difference of temperature between the junctions. The thermoelectric power varies with the temperature, thus: thermoelectric power $= Q = dE/dt = A + Bt$, where A is the thermoelectric power at 0° *C.*, B is a constant, and t is the mean temperature of the junctions. The neutral point is the temperature at which $dE/dt = 0$, and its value is $-A/B$. When a current is caused to flow in a circuit of two metals originally at a uniform temperature, heat is liberated at one of the junctions and absorbed at the other. The rate of production or liberation of heat at each junction, or Peltier effect, is given in calories per second, by multiplying the current by the coefficient of the Peltier effect. This coefficient in calories per coulomb $= QT/J$, in which Q is in volts, T is the absolute temperature of the junction, and $J = 4.19$. Heat is also liberated or absorbed in each of the metals as the current flows through portions of varying temperature. The rate of production or liberation of heat in each metal, or the Thomson effect, is given in calories per second by multiplying the current by the coefficient of the Thomson effect. This coefficient, in calories per coulomb, $= BT\theta/J$, in which B is in volts per degree C., T is the mean absolute temperature of the junctions, and θ is the difference of temperature of the junctions. (BT) is Sir W. Thomson's "Specific Heat of electricity." The algebraic signs are so chosen in the following table that when A is positive, the current flows in the metal considered from the cold junction to the hot. When B is positive, Q increases (algebraically) with the temperature. The values of A, B, and thermoelectric power, in the following table are with respect to lead as the other metal of the thermoelectric circuit. The thermoelectric power of a couple composed of two metals, 1 and 2, is given by subtracting the value for 2 from that for 1; when this difference is positive, the current flows from the cold junction to the hot in 1. In the following table, A is given in microvolts, B in microvolts per degree C., and the neutral point in degrees C.

The table has been compiled from the results of Becquerel, Matthiessen and Tait; in reducing the results, the electromotive force of the Grove and Daniell cells has been taken as 1.95 and 1.07 volts. The value for constantin was reduced from results given in Landolt-Börnstein's tables. The thermoelectric powers of antimony and bismuth alloys are given by Becquerel in the reference given below.

Substance.	A Microvolts.	B Microvolts.	Thermoelectric power at mean temp. of junctions (microvolts).		Neutral point $-\frac{A}{B}$.	Authority.
			20° C.	50° C.		
Aluminum	0.76	—0.0039	0.68	0.56	195	T
Antimony, comm'l pressed wire	-	-	—6.0	-	-	M
" axial	-	-	—22.6		-	"
" equatorial	-	-	—26.4	-	-	"
" ordinary	-	-	—17.0	-	-	B
Argentan	11.94	0.0506	12.95	14.47	—236	T
"	-	-	-	12.7	-	B
Arsenic	-	-	13.56	-	-	M
Bismuth, comm'l pressed wire	-	-	97.0	-	-	"
" pure " "	-	-	89.0	-	-	"
" crystal, axial	-	-	65.0	-	-	"
" " equatorial	-	-	45.0	-	-	"
" commercial	-	-	-	39.9	-	B
Cadmium	—2.63	—0.0424	—3.48	—4.75	—62	T
" fused	-	-	-	—2.45	-	B
Cobalt	-	-	22.	-	-	M
Constantin	-	-	-	+19.3	-	-
Copper	—1.34	—0.0094	—1.52	—1.81	—143	T
" commercial	-	-	—0.10	-	-	M
" galvanoplastic	-	-	—3.8	-	-	"
Gold	-	-	—1.2	-	-	"
"	—2.80	—0.0101	—3.0	—3.30	[—277]	T
Iron	—17.15	0.0482	—16.2	—14.74	356	"
" pianoforte wire	-	-	—17.5	-	-	M
" commercial	-	-	-	—12.10	-	B
" "	-	-	-	—9.10	-	"
Lead	-	0.0000	0.00	0.00	-	-
Magnesium	—2.22	0.0094	—2.03	—1.75	236	T
Mercury	-	-	0.413	-	-	M
"	-	-	-	3.30	-	B
Nickel	-	-	-	15.50	-	"
" (—18° to 175°)	21.8	0.0506	22.8	24.33	[—431]	T
" (250°–300°)	83.57	—0.2384	-	-	-	"
" (above 340°)	3.04	0.0506	-	-	-	"

TABLES 266 (*continued*)-267.

THERMOELECTRIC POWER.

TABLE 266. — Thermoelectric Power (*continued*).

Substance.	*A* Microvolts.	*B* Microvolts.	Thermoelectric power at mean temp. of junctions (microvolts).		Neutral point $-\frac{A}{B}$.	Authority.
			20° C.	50° C.		
Palladium	6.18	0.0355	6.9	7.96	—174	T
"	-	-	-	6.9	-	B
Phosphorus (red)	-	-	—29.9	-	-	M
Platinum	-	-	—0.9	-	-	"
" (hardened)	—2.57	0.0074	—2.42	—2.20	347	T
" (malleable)	0.60	0.0109	8.82	1.15	—55	"
" wire	-	-	-	—0.94	-	B
" another specimen	-	-	-	2.14	-	"
Platinum-iridium alloys:						
85 % Pt+15 % Ir	—7.90	—0.0062	—8.03	—8.21	[—1274]	T
90 % Pt+10 % Ir	—5.90	0.0133	—5.63	—5.23	444	"
95 % Pt + 5 % Ir	—6.15	—0.0055	—6.26	—6.42	[—1118]	"
Selenium	-	-	—807.	-	-	M
Silver	—2.12	—0.0147	—2.41	—2.86	—144	T
" (pure hard)	-	-	—3.00	-	-	M
" wire	-	-	-	—2.18	-	B
Steel	—11.27	0.0325	—10.62	—9.65	347	T
Tellurium	-	-	—502.	-	-	M
"	-	-	-	—429.3	-	B
Tin (commercial)	-	-	-	—0.33	-	"
"	-	-	—0.1	-	-	M
"	0.43	—0.0055	0.33	0.16	78	T
Zinc	—2.32	—0.0238	—2.79	—3.51	—98	"
" pure pressed	-	-	—3.7	-	-	M

B	Ed. Becquerel, "Ann. de Chim. et de Phys." [4] vol. 8.
M	Matthiesen, "Pogg. Ann." vol. 103, reduced by Fleming Jenkin.
T	Tait, "Trans. R. S. E." vol. 27, reduced by Mascart.

TABLE 267. — Thermoelectric Power against Platinum.

One junction is supposed to be at 0° C; + indicates that the current flows from the 0° junction into the platinum. The rhodium and iridium were rolled, the other metals drawn.*

Temperature, °C.	Au.	Ag.	90%Pt+10%Pd.	10%Pt+90%Pd.	Pd.	90%Pt+10%Rh.	90%Pt+10%Ru.	Ir.	Rh.
—185	—0.15	—0.16	—0.11	+0.24	+0.77	-	—0.53	—0.28	—0.24
—80	—0.31	—0.30	—0.09	+0.15	+0.39	-	—0.39	—0.32	—0.31
+100	+0.74	+0.72	+0.26	—0.19	—0.56	-	+0.73	+0.65	+0.65
+200	+1.8	+1.7	+0.62	—0.31	—1.20	-	+1.6	+1.5	+1.5
+300	+3.0	+3.0	+1.0	—0.37	—2.0	+2.3	+2.6	+2.5	+2.6
+400	+4.5	+4.5	+1.5	—0.35	—2.8	+3.2	+3.6	+3.6	+3.7
+500	+6.1	+6.2	+1.9	—0.18	—3.8	+4.1	+4.6	+4.8	+5.1
+600	+7.9	+8.2	+2.4	+0.12	—4.9	+5.1	+5.7	+6.1	+6.5
+700	+9.9	+10.6	+2.9	+0.61	—6.3	+6.2	+6.9	+7.6	+8.1
+800	+12.0	+13.2	+3.4	+1.2	—7.9	+7.2	+8.0	+9.1	+9.9
+900	+14.3	+16.0	+3.8	+2.1	—9.6	+8.3	+9.2	+10.8	+11.7
+1000	+16.8	-	+4.3	+3.1	—11.5	+9.5	+10.4	+12.6	+13.7
+1100	-	-	+4.8	+4.2	—13.5	+10.6	+11.6	+14.5	+15.8
+(1300)	-	-	-	-	-	+13.1	+14.2	+18.6	+20.4
+(1500)	-	-	-	-	-	+15.6	+16.9	+23.1	+25.6

* Holborn and Day.

TABLE 268.

PELTIER EFFECT.

The coefficient of Peltier effect may be calculated from the constants *A* and *B* of Table 255, as there shown. Experimental results, expressed in slightly different units, are here given. The figures are for the heat production at a junction of copper and the metal named, in calories per ampere-hour. The current flowing from copper to the metal named, a positive sign indicates a warming of the junction. The temperature not being stated by either author, and Le Roux not giving the algebraic signs, these results are not of great value.

Metals.	Calories per ampere-hour.	
	Jahn.*	Le Roux.†
Antimony (Becquerel's)‡	-	13.02
" (commercial)	-	4.8
Bismuth (pure)	-	19.1
" (Becquerel's)§	-	25.8
Cadmium . . .	—0.616	0.46
German silver . . .	-	2.47
Iron	—3.613	2.5
Nickel	4.362	
Platinum	0.320	
Silver	—0.413	
Zinc	—0.585	0.39

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* "Wied. Ann." vol. 34, p. 767.
† "Ann. de Chim. et de Phys." (4) vol. 10, p. 201.
‡ Becquerel's antimony is 806 parts Sb+406 parts Zn+121 parts Bi.
§ Becquerel's bismuth is 10 parts Bi+1 part Sb.

TABLE 269.

VARIOUS DETERMINATIONS OF THE VALUE OF THE OHM.

Date.	Observer.	Method.	Value of B. A. unit in ohms.	Value of Siemens unit, B. A. unit.	Value of ohm in cms. of Hg.
1882	Lord Rayleigh .	Rotating coil . .	0.98651	0.95412	106.24
1883	Lord Rayleigh .	Lorenz method . .	.98677	.95412	106.21
1884	Mascart . . .	Induced current . .	.98611	.95374	106.33
1887	Rowland . . .	Mean of several methods	.98644	.95349	106.32
1887	Kohlrausch . .	Damping of magnets .	.98660	.95338	106.32
1882 1888	Glazebrook . .	Induced currents . .	.98665	.95352	106.29
1890	Wuilleumeier . .	Mean effect of induced currents . . .	.98686	.95355	106.31
1890	Duncan and Wilkes	Lorenz method . .	.98634	.95341	106.34
1891	Jones . . .	Lorenz method . .	–	–	106.31
1894	Jones . . .	Lorenz method . .	–	–	106.33
1895	Himstedt . .	Mean effect of induced current . . .	–	–	106.28
1897	Ayrton and Jones .	Lorenz method . .	(.98634)	–	106.27
1899	Guillet . . .	Mean effect of induced current, using a calibrated 1000-ohm coil . . .		–	106.20
		Means . . .	0.98651	0.95366	106.288
1883	Wild . . .	Damping of magnet .	–	–	106.03
1884	Wiedemann . .	Earth inductor . .	–	–	106.19
1884	H. F. Weber . .	Induced current . .	–	–	105.37
1884	H. F. Weber . .	Rotating coil . . .	–	–	106.16
1884	Roiti . . .	Mean effect of induced current, using German silver coils certified by makers		–	105.89
1885	Himstedt . .	Mean effect of induced current, using German silver coils certified by makers		–	105.98
1885	Lorenz . . .	Lorenz method . .	–	–	105.93
1889	Dorn . . .	Damping of magnet .	–	–	106.24

The legal value of the ohm is the resistance of a column of mercury of uniform cross-section, weighing 14.4521 gms., and having a length of 106.30 cms. This is known as the international ohm. Mercury ohms conforming to these specifications have been prepared in recent years at the Physikalisch-Technische Reichsanstalt and the National Physical Laboratory, and are now being set up at the Bureau of Standards. The wire standards of resistance at the above-named laboratories agree in value to within two parts in 100000. Hence there is a very close agreement in the values of precision resistances calibrated at these laboratories.

TABLE 270.

SPECIFIC RESISTANCE OF METALLIC WIRES.

This table is modified from the table compiled by Jenkin (1862) from Matthiessen's results by taking the resistance of silver, gold, and copper from the observed metre gramme value and assuming the densities found by Matthiessen, namely, 10.468, 19.265, and 8.95.

Substance.	Resistance at 0° C. of a wire one cm. long, one sq. cm. in section.	Resistance at 0° C. of a wire one metre long, one mm. in diam.	Resistance at 0° C. of a wire one metre long, weighing one gramme.	Resistance at 0° C. of a wire one foot long, $\frac{1}{1000}$ in. in diam.	Resistance at 0° C. of a wire one foot long, weighing one grain.	Percentage increase of resistance for 1° C. increase of temp. at 20° C.
Silver annealed . . .	1.460×10^{-6}	0.01859	.1523	8.781	.2184	0.377
" hard drawn . .	1.585 "	0.02019	.1659	9.538	.2379	–
Copper annealed . .	1.584 "	0.02017	.1421	9.529	.2037	0.388
" hard drawn . .	1.619 "	0.02062	.1449	9.741	.2078	–
Gold annealed . . .	2.088 "	0.02659	.4025	12.56	.5771	0.365
" hard drawn . .	2.125 "	0.02706	.4094	12.78	.5870	–
Aluminium annealed . .	2.906 "	0.03699	.0747	17.48	.1071	–
Zinc pressed . . .	5.613 "	0.07146	.4012	33.76	.5753	0.365
Platinum annealed . .	9.035 "	0.1150	1.934	54.35	2.772	–
Iron " . .	9.693 "	0.1234	.7551	58.31	1.083	–
Nickel " . .	12.43 "	0.1583	1.057	74.78	1.515	–
Tin pressed . . .	13.18 "	0.1678	.9608	79.29	1.377	0.365
Lead " . . .	19.14 "	0.2437	2.227	115.1	3.193	0.387
Antimony pressed . .	35.42 "	0.4510	2.379	213.1	3.410	0.389
Bismuth " . .	130.9 "	1.667	12.86	787.5	18.43	0.354
Mercury " . .	94.07 "	1.198	12.79	565.9	18.34	0.072
Platinum-silver, 2 parts Ag, 1 part Pt, by weight .	24.33 "	0.3098	2.919	146.4	4.186	0.031
German silver . . .	20.89 "	0.2660	1.825	125.7	2.617	0.044
Gold-silver, 2 parts Au, 1 part Ag, by weight .	10.84 "	0.1380	1.646	65.21	2.359	0.065

TABLE 271.

SPECIFIC RESISTANCE OF METALS.

The specific resistance is here given as the resistance, in microhms, per centimetre of a bar one square centimetre in cross section.

Substance.	Physical state.	Specific resistance.	Temp. °C.	Authority.
Aluminum . .	–	2.6–3.0	0	Various.
Antimony . .	–	35.4–45.8	0	"
"	Solid	182.8	Melting-point	De la Rive.
"	Liquid	129.2	"	"
"	–	137.7	860	"
Arsenic . . .	–	33.3	0	Matthiessen and Vogt.
Bismuth . .	Electrolytic soft	108.0	0	Van Aubel.
"	" hard	108.7	0	"
"	Commercial	110–268	0	Various.
Boron . . .	Pulverized and compressed	8×10^{10}	–	Moissan.
Cadmium . .	–	6.2–7.0	–	Various.
"	Solid	16.5	318	Vassura.
"	Liquid	37.9	318	"
Gold	–	2.04–2.09	0	Various.
Calcium . .	–	7.5	16.8	Matthiessen.
Cobalt . . .	–	9.8	0	"
Copper . . .	Annealed	1.55–1.63	0	Various.
"	Hard-drawn	1.61–1.68	0	"
Iron	Commercial	9.7–12.0	0	"
"	Electrolytic	11.2	Ordinary	Kohlrausch.
"	"	105.5	Red heat	"
"	"	114.8	Yellow heat	"
"	"	118.3	Iron magnetic heat	"
Steel	Cast	19.1	Ord. temp.	"
"	"	85.8	Red heat	"
"	"	104.4	Yellow heat	"
"	"	113.9	Nearly white heat	"
"	Tempered glass hard	$45.7\,(1 + .00161t)$	t	Barus and Strouhal.
"	" light yellow	$28.9\,(1 + .00244t)$	t	" "
"	" yellow	$26.3\,(1 + .00280t)$	t	" "
"	" blue	$20.5\,(1 + .00330t)$	t	" "
"	" light blue	$18.4\,(1 + .00360t)$	t	" "
"	" soft	$15.9\,(1 + .00423t)$	t	" "
Iron	Cast, hard	97.8	0	" "
"	" soft	74.4	0	" "
Indium . . .	–	8.38	0	Erhard.
Lead	–	18.4–19.6	0	Various.
Lithium . . .	–	8.8	20	Matthiessen.
Magnesium .	–	4.1–5.0	0	Various.
Nickel . . .	–	10.7–12.4	0	"
Palladium . .	–	10.6–13.6	0	"
Platinum . .	–	9.0–15.5	0	"
Potassium . .	–	25.1	0	Matthiessen.
"	Fluid	50.4	100	"
Silver . . .	–	1.5–1.7	0	Various.
Strontium . .	–	25.13	20	Matthiessen.
Tellurium . .	–	2.17×10^5	19.6	"
"	–	55.05	294	Vincentini and Omodei.
Tin	–	9.53–11.4	0	Various.
"	–	9.53	0	Vassura.
"	Solid	20.96	226.5	"
"	Liquid	44.56	226.5	"
Zinc	–	5.56–6.04	0	
"	Solid	18.16	Melting-point	De la Rive.
"	Liquid	36.00	"	"

TABLE 272.

RESISTANCE OF METALS AND

The electrical resistance of some pure metals and of some alloys have been determined by Dewar and Fleming and increases as the temperature is lowered. The resistance seems to approach zero for the pure metals, but not for temperature tried. The following table gives the results of Dewar and Fleming.*

When the temperature is raised above 0° C. the coefficient decreases for the pure metals, as is shown by the experiexperiments to be approximately true, namely, that the resistance of any pure metal is proportional to its absolute is greater the lower the temperature, because the total resistance is smaller. This rule, however, does not even zero Centigrade, as is shown in the tables of resistance of alloys. (Cf. Table 262.)

Temperature =	100°	20°	0°	−80°
Metal or alloy.	Specific resistance in c. g. s. units.			
Aluminium, pure hard-drawn wire	4745	3505	3161	–
Copper, pure electrolytic and annealed	1920	1457	1349	–
Gold, soft wire	2665	2081	1948	1400
Iron, pure soft wire	13970†	9521	8613	–
Nickel, pure (prepared by Mond's process from compound of nickel and carbon monoxide)	19300	13494	12266	7470
Platinum, annealed	10907	8752	8221	6133
Silver, pure wire	2139	1647	1559	1138
Tin, pure wire	13867	10473	9575	6681
German silver, commercial wire	35720	34707	34524	33664
Palladium-silver, 20 Pd + 80 Ag	15410	14984	14961	14482
Phosphor-bronze, commercial wire	9071	8588	8479	8054
Platinoid, Martino's platinoid with 1 to 2% tungsten	44590	43823	43601	43022
Platinum-iridium, 80 Pt + 20 Ir	31848	29902	29374	27504
Platinum-rhodium, 90 Pt + 10 Rh	18417	14586	13755	10778
Platinum-silver, 66.7 Ag + 33.3 Pt	27404	26915	26818	26311
Carbon, from Edison-Swan incandescent lamp	–	4046×10^8	4092×10^8	4189×10^8
Carbon, from Edison-Swan incandescent lamp	3834×10^8	3908×10^8	3955×10^8	4054×10^8
Carbon, adamantine, from Woodhouse and Rawson incandescent lamp	6168×10^8	6300×10^8	6363×10^8	6495×10^8

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* "Phil. Mag." vol. 34, 1892.

† This is given by Dewar and Fleming as 13777 for 96°.4, which appears from the other measurements too high.

ALLOYS AT LOW TEMPERATURES.

by Cailletet and Bouty at very low temperatures. The results show that the coefficient of change with temperature the alloys. The resistance of carbon was found by Dewar and Fleming to increase continuously to the lowest

ments or Müller, Benoit, and others. Probably the simplest rule is that suggested by Clausius, and shown by these temperature. This gives the actual change of resistance per degree, a constant; and hence the percentage of change approximately hold for alloys, some of which have a negative temperature coefficient at temperatures not far from

Temperature =	−100°	−182°	−197°	Mean value of temperature coefficient between −100° and +100° C.*
Metal or alloy.	Specific resistance in c. g. s. units.			
Aluminum, pure hard-drawn wire	1928	894		.00446
Copper, pure electrolytic and annealed	757	272	178	431
Gold, soft wire	1207	604	-	375
Iron, pure soft wire	4010	1067	608	578
Nickel, pure (prepared by Mond's process from compound of nickel and carbon monoxide)	6110	1900	-	538
Platinum, annealed	5295	2821	2290	341
Silver, pure wire	962	472	-	377
Tin, pure wire	5671	2553	-	428
German silver, commercial wire	33280	32512	-	035
Palladium-silver, 20 Pd + 80 Ag	14256	13797	-	039
Phosphor-bronze, commercial wire	7883	7371		070
Platinoid, Martino's platinoid with 1 to 2% tungsten	42385	41454	-	025
Platinum-iridium, 80 Pt + 20 Ir	26712	24440		087
Platinum-rhodium, 90 Pt + 10 Rh	9834	7134	-	312
Platinum-silver, 66.7 Ag + 33.3 Pt	26108	25537	-	024
Carbon, from Edison-Swan incandescent lamp	4218×10^8	4321×10^8	-	-
Carbon, from Edison-Swan incandescent lamp	4079×10^8	4180×10^8	-	031
Carbon, adamantine, from Woodhouse and Rawson incandescent lamp	6533×10^8	-	-	029

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* This is α in the equation $R = R_0 (1 + \alpha t)$, as calculated from the equation $\alpha = \frac{R_{100} - R_{-100}}{200 R_0}$.

TABLE 273.

CONDUCTIVITY OF THREE-METAL AND MISCELLANEOUS ALLOYS.

Conductivity in mhos or $\frac{1}{\text{ohms per cm. cube}} = C_t = C_0 (1 - at + bt^2)$.

Metals and alloys.	Composition by weight.	$\frac{C_0}{10^4}$	$a \times 10^6$	$b \times 10^9$	Authority.
Gold-copper-silver . . .	58.3 Au + 26.5 Cu + 15.2 Ag	7.58	574	924	1
" " " . . .	66.5 Au + 15.4 Cu + 18.1 Ag	6.83	529	93	1
" " " . . .	7.4 Au + 78.3 Cu + 14.3 Ag	28.06	1830	7280	1
Nickel-copper-zinc . . .	12.84 Ni + 30.59 Cu + 6.57 Zn by volume . . .	4.92	444	51	1
Brass	Various	12.2–15.6	1–2 × 10³	–	2
" hard drawn . . .	70.2 Cu + 29.8 Zn	12.16	–	–	3
" annealed	" "	14.35	–	–	3
German silver	Various	3–5	–	–	2
" "	60.16 Cu + 25.37 Zn + 14.03 Ni + .30 Fe with trace of cobalt and manganese .	3.33	360	–	4
Aluminum bronze . . .	– – –	7.5–8.5	5–7 × 10²	–	2
Phosphor bronze . . .	– – –	10–20	–	–	2
Silicium bronze	– – –	41	–	–	5
Manganese-copper . . .	30 Mn + 70 Cu	1.00	40	–	4
Nickel-manganese-copper	3 Ni + 24 Mn + 73 Cu . .	2.10	—30	–	4
Nickelin	18.46 Ni + 61.63 Cu + 19.67 Zn + 0.24 Fe + 0.19 Co + 0.18 Mn . . .	3.01	300	–	4
Patent nickel	25.1 Ni + 74.41 Cu + 0.42 Fe + 0.23 Zn + 0.13 Mn + trace of cobalt	2.92	190	–	4
Rheotan	53.28 Cu + 25.31 Ni + 16.89 Zn + 4.46 Fe + 0.37 Mn	1.90	410	–	4
Copper-manganese-iron .	91 Cu + 7.1 Mn + 1.9 Fe .	4.98	120	–	6
" " " .	70.6 Cu + 23.2 Mn + 6.2 Fe	1.30	22	–	6
" " " .	69.7 Cu + 29.9 Ni + 0.3 Fe .	2.60	120	–	7
Manganin	84 Cu + 12 Mn + 4 Ni . . .	2.3	0–42	300–600	2
Constantan	60 Cu + 40 Ni	2.04	18	–	8

[1] Matthiessen.
[2] Various.
[3] W. Siemens.
[4] Feussner and Lindeck.
[5] Van der Ven.
[6] Blood.
[6] Feussner.
[7] Jaeger-Diesselhorst.

TABLE 274.

CONDUCTING POWER OF ALLOYS.

This table shows the conducting power of alloys and the variation of the conducting power with temperature.* The values of C_0 were obtained from the original results by assuming silver $= \frac{10^6}{1.585}$ mhos. The conductivity is taken as $C_t = C_0\,(1 - at + bt^2)$, and the range of temperature was from 0° to 100° C.

The table is arranged in three groups to show (1) that certain metals when melted together produce a solution which has a conductivity equal to the mean of the conductivities of the components, (2) the behavior of those metals alloyed with others, and (3) the behavior of the other metals alloyed together.

It is pointed out that, with a few exceptions, the percentage variation between 0° and 100° can be calculated from the formula $P = P_c \frac{l}{l'}$, where l is the observed and l' the calculated conducting power of the mixture at 100° C., and P_c is the calculated mean variation of the metals mixed.

Alloys.	Weight %	Volume %	$\frac{C_0}{10^4}$	$a \times 10^8$	$b \times 10^9$	Variation per 100° C.	
	of first named.					Observed.	Calculated.
GROUP 1.							
Sn_6Pb	77.04	83.96	7.57	3890	8670	30.18	29.67
Sn_4Cd	82.41	83.10	9.18	4080	11870	28.89	30.03
SnZn	78.06	77.71	10.56	3880	8720	30.12	30.16
PbSn	64.13	53.41	6.40	3780	8420	29.41	29.10
$ZnCd_2$	24.76	26.06	16.16	3780	8000	29.86	29.67
$SnCd_4$	23.05	23.50	13.67	3850	9410	29.08	30.25
$CdPb_6$	7.37	10.57	5.78	3500	7270	27.74	27.60
GROUP 2.							
Lead-silver ($Pb_{20}Ag$)	95.05	94.64	5.60	3630	7960	28.24	19.96
Lead-silver (PbAg)	48.97	46.90	8.03	1960	3100	16.53	7.73
Lead-silver ($PbAg_2$)	32.44	30.64	13.80	1990	2600	17.36	10.42
Tin-gold ($Sn_{12}Au$)	77.94	90.32	5.20	3080	6640	24.20	14.83
" " (Sn_5Au)	59.54	79.54	3.03	2920	6300	22.90	5.95
Tin-copper	92.24	93.57	7.59	3680	8130	28.71	19.76
" " †	80.58	83.60	8.05	3330	6840	26.24	14.57
" " †	12.49	14.91	5.57	547	294	5.18	3.99
" " †	10.30	12.35	6.41	666	1185	5.48	4.46
" " †	9.67	11.61	7.64	691	304	6.60	5.22
" " †	4.96	6.02	12.44	995	705	9.25	7.83
" " †	1.15	1.41	39.41	2670	5070	21.74	20.53
Tin-silver	91.30	96.52	7.81	3820	8190	30.00	23.31
" "	53.85	75.51	8.65	3770	8550	29.18	11.89
Zinc-copper †	36.70	42.06	13.75	1370	1340	12.40	11.29
" " †	25.00	29.45	13.70	1270	1240	11.49	10.08
" " †	16.53	23.61	13.44	1880	1800	12.80	12.30
" " †	8.89	10.88	29.61	2040	3030	17.41	17.42
" " †	4.06	5.03	38.09	2470	4100	20.61	20.62

NOTE. — Barus, in the "Am. Jour. of Sci." vol. 36, has pointed out that the temperature variation of platinum alloys containing less than 10% of the other metal can be nearly expressed by an equation $y = \frac{n}{x} - m$, where y is the temperature coefficient and x the specific resistance, m and n being constants. If a be the temperature coefficient at 0° C. and s the corresponding specific resistance, $s\,(a + m) = n$.

For platinum alloys Barus's experiments gave $m = -.000194$ and $n = .0378$.
For steel $m = -.000303$ and $n = .0620$.

Matthiessen's experiments reduced by Barus gave for

Gold alloys $m = -.000045$, $n = .00721$.
Silver " $m = -.000112$, $n = .00538$.
Copper " $m = -.000386$, $n = .00055$.

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* From the experiments of Matthiessen and Vogt, "Phil. Trans. R. S." v. 154.
† Hard-drawn.

TABLE 274 (*continued*).

CONDUCTING POWER OF ALLOYS.

Group 3.

Alloys.	Weight %	Volume %	$\frac{C_0}{10^4}$	$a \times 10^6$	$b \times 10^9$	Variation per 100° C.	
	of first named.					Observed.	Calculated.
Gold-copper †	99.23	98.36	35.42	2650	4650	21.87	23.22
" " †	90.55	81.66	10.16	749	81	7.41	7.53
Gold-silver †	87.95	79.86	13.46	1090	793	10.09	9.65
" " *	87.95	79.86	13.61	1140	1160	10.21	9.59
" " †	64.80	52.08	9.48	673	246	6.49	6.58
" " *	64.80	52.08	9.51	721	495	6.71	6.42
" " †	31.33	19.86	13.69	885	531	8.23	8.62
" " *	31.33	19.86	13.73	908	641	8.44	8.31
Gold-copper †	34.83	19.17	12.94	864	570	8.07	8.18
" " †	1.52	0.71	53.02	3320	7300	25.90	25.86
Platinum-silver †	33.33	19.65	4.22	330	208	3.10	3.21
" " †	9.81	5.05	11.38	774	656	7.08	7.25
" " †	5.00	2.51	19.96	1240	1150	11.29	11.88
Palladium-silver †	25.00	23.28	5.38	324	154	3.40	4.21
Copper-silver †	98.08	98.35	56.49	3450	7990	26.50	27.30
" " †	94.40	95.17	51.93	3250	6940	25.57	25.41
" " †	76.74	77.64	44.06	3030	6070	24.29	21.92
" " †	42.75	46.67	47.29	2870	5280	22.75	24.00
" " †	7.14	8.25	50.65	2750	4360	23.17	25.57
" " †	1.31	1.53	50.30	4120	8740	26.51	29.77
Iron-gold †	13.59	27.93	1.73	3490	7010	27.92	14.70
" " †	9.80	21.18	1.26	2970	1220	17.55	11.20
" " †	4.76	10.96	1.46	487	103	3.84	13.40
Iron-copper †	0.40	0.46	24.51	1550	2090	13.44	14.03
Phosphorus-copper †	2.50	–	4.62	476	145	–	–
" " †	0.95	–	14.91	1320	1640	–	–
Arsenic-copper †	5.40	–	3.97	516	989	–	–
" " †	2.80	–	8.12	736	446	–	–
" " †	trace	–	38.52	2640	4830	–	–

* Annealed.

† Hard-drawn.

TABLE 275.

ELECTRICAL RESISTANCE OF STRAIGHT WIRES WITH ALTERNATING CURRENTS OF DIFFERENT FREQUENCIES.

This table gives the ratio of the resistance of straight copper wires with alternating currents of different frequencies to the value of the resistance with direct currents.

Diameter of wire in millimeters.	Frequency $n =$					
	60	100	1000	10000	100000	1000000
0.05	-	-	-	-	-	*1.001
0.1	-	-	-	-	*1.001	1.008
0.25	-	-	-	-	1.003	1.247
0.5	-	-	-	*1.001	1.047	2.240
1.0	-	-	-	1.008	1.503	4.19
2	-	-	1.001	1.120	2.756	
3	-	-	1.006	1.437	4.00	
4	-	-	1.021	1.842		
5	-	*1.001	1.047	2.240		
7.5	1.001	1.002	1.210	3.22		
10	1.003	1.008	1.503	4.19		
15	1.016	1.038	2.136			
20	1.044	1.120	2.756			
25	1.105	1.247	3.38			
40	1.474	1.842				
100	3.31	4.19				

Values between 1.000 and 1.001 are indicated by *1.001.

The change of resistance of wires other than copper (iron wires excepted) may be calculated from the above table, making use of the fact that the change of resistance is a function of the argument $p = 2\pi r\sqrt{2n\lambda}$ where r = radius of cross-section, n = frequency, λ = conductivity.

If a given wire be wound into a solenoid, its resistance, at a given frequency, will be greater than the values in the table, which apply to straight wires only. The resistance in this case is a complicated function of the pitch and radius of the winding, the frequency, and the diameter of the wire, and is found by experiment to be sometimes as much as twice the value for a straight wire.

Table 276.

INTERNATIONAL ATOMIC WEIGHTS AND ELECTROCHEMICAL EQUIVALENTS.

The International Atomic Weights are quoted from the report of the International Committee on Atomic Weights (“Jour. Am. Chem. Soc.,” vol. 32, p. 3, 1910).

With the exception of the value given for silver and that corresponding to valence 2 for copper, the electrochemical equivalents given in this table have been calculated from the atomic weights and one or two of the more common apparent valences of the substance. The value given for silver is that which was adopted by the International Congress of Electricians at Chicago in 1894.

Substance.	Symbol.	Relative atomic wt. Oxygen = 16.	Relative atomic wt. Hydrogen = 1.	Valence.	Electrochemical equivalent in grammes per coulomb × 1000.
Aluminum	Al	27.1	26.9	3	.0936
Antimony	Sb	120.2	119.3	3	.4152
“	“	“	“	5	.2491
Argon	A	39.9	39.6	–	–
Arsenic	As	74.96	74.4	3	.2590
“	“	“	“	5	.1554
Barium	Ba	137.37	136.27	2	.7118
Bismuth	Bi	208.0	206.3	3	.7185
“	“	“	“	5	.4311
Boron	B	11.0	10.9	3	.0380
Bromine	Br	79.92	79.28	1	.8282
Cadmium	Cd	112.40	111.51	2	0.5824
Cæsium	Cs	132.81	131.76	1	1.3764
Calcium	Ca	40.09	39.77	2	0.2077
Carbon	C	12.00	11.99	4	.0313
Cerium	Ce	140.25	139.14	2	.7267
Chlorine	Cl	35.46	35.19	1	.3675
Chromium	Cr	52.0	51.6	3	.1797
“	“	“	“	6	.0900
Cobalt	Co	58.97	58.50	2	.3061
“	“	“	“	3	.2041
Columbium	Cb	93.5	92.8	5	.1937
Copper	Cu	63.57	63.07	1	.6588
“	“	“	“	2	.3290
Dysprosium	Dy	162.5	161.2	–	–
Erbium	Er	167.4	166.1	2	.8624
Europium	Eu	152.0	150.8	–	–
Fluorine	F	19.0	18.9	1	.1968
Gadolinium	Gd	157.3	156.1	–	–
Gallium	Ga	69.9	69.3	3	.2414
Germanium	Ge	72.5	71.9	–	–
Glucinum	Gl	9.1	9.03	2	.0471
Gold	Au	197.2	195.7	3	.6818
Helium	He	4.0	4.0	–	–
Hydrogen	H	1.008	1.000	1	.0104
Indium	In	114.8	113.9	3	0.3966
Iodine	I	126.92	125.91	1	1.3153
Iridium	Ir	193.1	191.6	4	0.5003
Iron	Fe	55.85	55.41	2	.2894
“	“	“	“	3	.1929
Krypton	Kr	83.0	82.4	–	–
Lanthanum	La	139.0	137.9	2	0.7202
Lead	Pb	207.10	205.46	2	1.0731
Lithium	Li	7.00	6.94	1	0.0725
Lutecium	Lu	174.0	172.6	–	–
Magnesium	Mg	24.32	24.13	2	.1260
Manganese	Mn	54.93	54.49	2	.2846
“	“	“	“	4	.1423

INTERNATIONAL ATOMIC WEIGHTS AND ELECTROCHEMICAL EQUIVALENTS.

Substance.	Symbol.	Relative atomic wt. Oxygen = 16.	Relative atomic wt. Hydrogen = 1.	Valence.	Electrochemical equivalent in grammes per coulomb × 1000.
Mercury	Hg	200.0	198.5	1	2.0727
"	"	"	"	2	1.0363
Molybdenum	Mo	96.0	95.3	6	0.1658
Neodymium	Nd	144.3	143.2	–	–
Neon	Ne	20.0	19.9	–	–
Nickel	Ni	58.68	58.21	2	.3040
"	"	"	"	3	.2027
Nitrogen	N	14.01	13.90	3	.0484
"	"	"	"	5	.0290
Osmium	Os	190.9	189.4	6	.3297
Oxygen	O	16.00	15.88	2	.0829
Palladium	Pd	106.7	105.9	2	.5528
"	"	"	"	5	.2211
Phosphorus	P	31.0	30.8	3	.1071
"	"	"	"	5	0.0642
Platinum	Pt	195.0	193.4	2	1.0104
"	"	"	"	4	0.5052
Potassium	K	39.10	38.79	1	.4052
Præsodymium	Pr	140.6	139.5	–	–
Radium	Rd	226.4	224.6	–	–
Rhodium	Rh	102.9	102.1	3	.3554
Rubidium	Rb	85.45	84.77	1	.8855
Ruthenium	Ru	101.7	100.9	4	.2635
Samarium	Sa	150.4	149.2	–	
Scandium	Sc	44.1	43.7	–	–
Selenium	Se	79.2	78.6	2	.4104
Silicon	Si	28.3	28.2	4	0.0733
Silver	Ag	107.88	107.02	1	1.1180
Sodium	Na	23.00	22.82	1	0.2384
Strontium	Sr	87.62	86.92	2	.4540
Sulphur	S	32.07	31.82	2	.1662
Tantalum	Ta	181.0	179.6	5	.3751
Tellurium	Te	127.5	126.5	2	0.6606
Terbium	Tb	159.2	157.9	–	–
Thallium	Tl	204.0	202.4	1	2.1141
Thorium	Th	232.42	230.57	2	1.2043
Thulium	Tm	168.5	167.2	–	–
Tin	Sn	119.0	118.1	2	0.6166
"	"	"	"	4	.3083
Titanium	Ti	48.1	47.7	4	.1246
Tungsten	W	184.	183.	6	0.3178
Uranium	U	238.5	236.6	2	1.2358
"	"	"	"	3	0.8238
Vanadium	V	51.2	50.8	3	.1768
"	"	"	"	5	.1061
Xenon	Xe	130.7	129.7	–	–
Ytterbium	Yb	172.0	170.6	–	–
Yttrium	Yt	89.0	88.3	2	.4611
Zinc	Zn	65.37	64.88	2	.3385
Zirconium	Zr	90.6	89.9	4	.2347

CONDUCTIVITY OF ELECTROLYTIC SOLUTIONS.

This subject has occupied the attention of a considerable number of eminent workers in molecular physics, and a few results are here tabulated. It has seemed better to confine the examples to the work of one experimenter, and the tables are quoted from a paper by F. Kohlrausch,* who has been one of the most reliable and successful workers in this field.

The study of electrolytic conductivity, especially in the case of very dilute solutions, has furnished material for generalizations, which may to some extent help in the formation of a sound theory of the mechanism of such conduction. If the solutions are made such that per unit volume of the solvent medium there are contained amounts of the salt proportional to its electrochemical equivalent, some simple relations become apparent. The solutions used by Kohlrausch were therefore made by taking numbers of grammes of the pure salts proportional to their electrochemical equivalent, and using a litre of water as the standard quantity of the solvent. Taking the electrochemical equivalent number as the chemical equivalent or atomic weight divided by the valence, and using this number of grammes to the litre of water, we get what is called the normal or gramme molecule per litre solution. In the table, *m* is used to represent the number of gramme molecules to the litre of water in the solution for which the conductivities are tabulated. The conductivities were obtained by measuring the resistance of a cell filled with the solution by means of a Wheatstone bridge alternating current and telephone arrangement. The results are for 18° C., and relative to mercury at 0° C., the cell having been standardized by filling with mercury and measuring the resistance. They are supposed to be accurate to within one per cent of the true value.

The tabular numbers were obtained from the measurements in the following manner: —

Let K_{18} = conductivity of the solution at 18° C. relative to mercury at 0° C.

K^w_{18} = conductivity of the solvent water at 18° C. relative to mercury at 0° C.

Then $K_{18} - K^w_{18} = k_{18}$ = conductivity of the electrolyte in the solution measured.

$\frac{k_{18}}{m} = \mu$ = conductivity of the electrolyte in the solution per molecule, or the "specific molecular conductivity."

TABLE 277. — Value of k_{18} for a few Electrolytes.

This short table illustrates the apparent law that the conductivity in very dilute solutions is proportional to the amount of salt dissolved.

m	KCl	$NaCl$	$AgNO_3$	$KC_2H_3O_2$	K_2SO_4	$MgSO_4$
0.000001	1.216	1.024	1.080	0.939	1.275	1.056
0.00002	2.434	2.056	2.146	1.886	2.532	2.104
0.00006	7.272	6.162	6.462	5.610	7.524	6.216
0.0001	12.09	10.29	10.78	9.34	12.49	10.34

TABLE 278. — Electro-Chemical Equivalents and Normal Solutions.

The following table of the electro-chemical equivalent numbers and the densities of approximately normal solutions of the salts quoted in Table 271 may be convenient. They represent grammes per cubic centimetre of the solution at the temperature given.

Salt dissolved.	Grammes per litre.	*m*	Temp. C.	Density.	Salt dissolved.	Grammes per litre.	*m*	Temp. C.	Density.
KCl . . .	74.59	1.0	15.2	1.0457	$\frac{1}{2}K_2SO_4$.	87.16	1.0	18.9	1.0658
NH_4Cl . .	53.55	1.0009	18.6	1.0152	$\frac{1}{2}Na_2SO_4$.	71.09	1.0003	18.6	1.0602
$NaCl$ . . .	58.50	1.0	18.4	1.0391	$\frac{1}{2}Li_2SO_4$.	55.09	1.0007	18.6	1.0445
$LiCl$ . . .	42.48	1.0	18.4	1.0227	$\frac{1}{2}MgSO_4$.	60.17	1.0023	18.6	1.0573
$\frac{1}{2}BaCl_2$ . .	104.0	1.0	18.6	1.0888	$\frac{1}{2}ZnSO_4$.	80.58	1.0	5.3	1.0794
$\frac{1}{2}ZnCl_2$ . .	68.0	1.012	15.0	1.0592	$\frac{1}{2}CuSO_4$.	79.9	1.001	18.2	1.0776
KI	165.9	1.0	18.6	1.1183	$\frac{1}{2}K_2CO_3$.	69.17	1.0006	18.3	1.0576
KNO_3 . .	101.17	1.0	18.6	1.0601	$\frac{1}{2}Na_2CO_3$.	53.04	1.0	17.9	1.0517
$NaNO_3$ . .	85.08	1.0	18.7	1.0542	KOH . .	56.27	1.0025	18.8	1.0477
$AgNO_3$ . .	169.9	1.0	–	–	HCl . .	36.51	1.0041	18.6	1.0161
$\frac{1}{2}Ba(NO_3)_2$.	65.28	0.5	–	–	HNO_3 . .	63.13	1.0014	18.6	1.0318
$KClO_3$ . .	61.29	0.5	18.3	1.0367	$\frac{1}{2}H_2SO_4$.	49.06	1.0006	18.9	1.0300
$KC_2H_3O_2$.	98.18	1.0005	18.6	1.0467					

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* "Wied. Ann." vol. 26, pp. 161–226.

TABLE 279.

SPECIFIC MOLECULAR CONDUCTIVITY μ: MERCURY $= 10^8$.

Salt dissolved.	$m = 10$	5	3	1	0.5	0.1	.05	.03	.01
$\frac{1}{2}K_2SO_4$	–	–	–	–	672	736	897	959	1098
KCl	–	–	827	919	958	1047	1083	1107	1147
KI	–	770	900	968	997	1069	1102	1123	1161
NH_4Cl	–	752	825	907	948	1035	1078	1101	1142
KNO_3	–	–	572	752	839	983	1037	1067	1122
$\frac{1}{2}BaCl_2$	–	–	487	658	725	861	904	939	1006
$KClO_3$	–	–	–	–	799	927	(976)	1006	1053
$\frac{1}{2}Ba_2N_2O_6$	–	–	–	–	531	755	828	(870)	951
$\frac{1}{2}CuSO_4$	–	–	150	241	288	424	479	537	675
$AgNO_3$	–	351	448	635	728	886	936	(966)	1017
$\frac{1}{2}ZnSO_4$	–	82	146	249	302	431	500	556	685
$\frac{1}{2}MgSO_4$	–	82	151	270	330	474	532	587	715
$\frac{1}{2}Na_2SO_4$	–	–	–	475	559	734	784	828	906
$\frac{1}{2}ZnCl_2$	60	180	280	514	601	768	817	851	915
$NaCl$	–	398	528	695	757	865	897	(920)	962
$NaNO_3$	–	–	430	617	694	817	855	877	907
$KC_2H_3O_2$	30	240	381	594	671	784	820	841	879
$\frac{1}{2}Na_2CO_3$	–	–	254	427	510	682	751	799	899
$\frac{1}{2}H_2SO_4$	660	1270	1560	1820	1899	2084	2343	2515	2855
C_2H_4O	0.5	2.6	5.2	12	19	43	62	79	132
HCl	600	1420	2010	2780	3017	3244	3330	3369	3416
HNO_3	610	1470	2070	2770	2991	3225	3289	3328	3395
$\frac{1}{3}H_3PO_4$	148	160	170	200	250	430	540	620	790
KOH	423	990	1314	1718	1841	1986	2045	2078	2124
NH_3	0.5	2.4	3.3	8.4	12	31	43	50	92

Salt dissolved.	.006	.002	.001	.0006	.0002	.0001	.00006	.00002	.00001
$\frac{1}{2}K_2SO_4$	1130	1181	1207	1220	1241	1249	1254	1266	1275
KCl	1162	1185	1193	1199	1209	1209	1212	1217	1216
KI	1176	1197	1203	1209	1214	1216	1216	1216	1207
NH_4Cl	1157	1180	1190	1197	1204	1209	1215	1209	1205
KNO_3	1140	1173	1180	1190	1199	1207	1220	1198	1215
$\frac{1}{2}BaCl_2$	1031	1074	1092	1102	1118	1126	1133	1144	1142
$KClO_3$	1068	1091	1101	1109	1119	1122	1126	1135	1141
$\frac{1}{2}Ba_2N_2O_6$	982	1033	1054	1066	1084	1096	1100	1114	1114
$\frac{1}{2}CuSO_4$	740	873	950	987	1039	1062	1074	1084	1086
$AgNO_3$	1033	1057	1068	1069	1077	1078	1077	1073	1080
$\frac{1}{2}ZnSO_4$	744	861	919	953	1001	1023	1032	1047	1060
$\frac{1}{2}MgSO_4$	773	881	935	967	1015	1034	1036	1052	1056
$\frac{1}{2}Na_2SO_4$	933	980	998	1009	1026	1034	1038	1056	1054
$\frac{1}{2}ZnCl_2$	939	979	994	1004	1020	1029	1031	1035	1036
$NaCl$	976	998	1008	1014	1018	1029	1027	1028	1024
$NaNO_3$	921	942	952	956	966	975	970	972	975
$KC_2H_3O_2$	891	913	919	923	933	934	935	943	939
$\frac{1}{2}Na_2CO_3$	956	1010	1037	1046	988	874	790	715	697*
$\frac{1}{2}H_2SO_4$	3001	3240	3316	3342	3280	3118	2927	2077	1413*
C_2H_4O	170	283	380	470	796	995	1133	1328	1304*
HCl	3438	3455	3455	3440	3340	3170	2968	2057	1254*
HNO_3	3421	3448	3427	3408	3285	3088	2863	1904	1144*
$\frac{1}{3}H_3PO_4$	858	945	968	977	920	837	746	497	402*
KOH	2141	2140	2110	2074	1892	1689	1474	845	747*
NH_3	116	190	260	330	500	610	690	700	560*

* Acids and alkaline salts show peculiar irregularities.

LIMITING VALUES OF μ. TEMPERATURE COEFFICIENTS.

TABLE 280. — Limiting Values of μ.

This table shows limiting values of $\mu = \frac{k}{m} . 10^8$ for infinite dilution for neutral salts, calculated from Table 271.

Salt.	μ	Salt.	μ	Salt.	μ	Salt.	μ
$\frac{1}{2}K_2SO_4$.	1280	$\frac{1}{2}BaCl_2$.	1150	$\frac{1}{2}MgSO_4$.	1080	$\frac{1}{2}H_2SO_4$.	3700
KCl . . .	1220	$\frac{1}{2}KClO_3$.	1150	$\frac{1}{2}Na_2SO_4$.	1060	HCl . .	3500
KI . . .	1220	$\frac{1}{2}BaN_2O_6$.	1120	$\frac{1}{2}ZnCl$ . .	1040	HNO_3 . .	3500
NH_4Cl . .	1210	$\frac{1}{2}CuSO_4$.	1100	NaCl . .	1030	$\frac{1}{3}H_3PO_4$.	1100
KNO_3 . .	1210	$AgNO_3$.	1090	$NaNO_3$.	980	KOH . .	2200
–	–	$\frac{1}{2}ZnSO_4$.	1080	$K_2C_2H_3O_2$	940	$\frac{1}{2}Na_2CO_3$.	1400

If the quantities in Table 271 be represented by curves, it appears that the values of the specific molecular conductivities tend toward a limiting value as the solution is made more and more dilute. Although these values are of the same order of magnitude, they are not equal, but depend on the nature of both the ions forming the electrolyte.

When the numbers in Table 272 are multiplied by Hittorf's constant, or 0.00011, quantities ranging between 0.14 and 0.10 are obtained which represent the velocities in millimetres per second of the ions when the electromotive force gradient is one volt per millimetre.

Specific molecular conductivities in general become less as the concentration is increased, which may be due to mutual interference. The decrease is not the same for different salts, but becomes much more rapid in salts of high valence.

Salts having acid or alkaline reactions show marked differences. They have small specific molecular conductivity in very dilute solutions, but as the concentration is increased the conductivity rises, reaches a maximum and again falls off. Kohlrausch does not believe that this can be explained by impurities. H_3PO_4 in dilute solution seems to approach a monobasic acid, while H_2SO_4 shows two maxima, and like H_3PO_4 approaches in very weak solution to a monobasic acid.

Kohlrausch concludes that the law of independent migration of the ions in media like water is sustained.

TABLE 281. — Temperature Coefficients.

The temperature coefficient in general diminishes with dilution, and for very dilute solutions appears to approach a common value. The following table gives the temperature coefficient for solutions containing 0.01 gramme molecule of the salt.

Salt.	Temp. Coeff.	Salt.	Temp. Coeff.	Salt.	Temp. Coeff.	Salt.	Temp. Coeff.
KCl . . .	0.0221	KI . . .	0.0219	$\frac{1}{2}K_2SO_4$.	0.0223	$\frac{1}{2}K_2CO_3$ . .	0.0249
NH_4Cl . .	0.0226	KNO_3 . .	0.0216	$\frac{1}{2}Na_2SO_4$.	0.0240	$\frac{1}{2}Na_2CO_3$ . .	0.0265
NaCl . .	0.0238	$NaNO_3$ . .	0.0226	$\frac{1}{2}Li_2SO_4$.	0.0242	KOH . . .	0.0194
LiCl . . .	0.0232	$AgNO_3$ . .	0.0221	$\frac{1}{2}MgSO_4$.	0.0236	HCl . . .	0.0159
$\frac{1}{2}BaCl_2$ . .	0.0234	$\frac{1}{2}Ba(NO_3)_2$	0.0224	$\frac{1}{2}ZnSO_3$.	0.0234	HNO_3 . . .	0.0162
$\frac{1}{2}ZnCl_2$ . .	0.0239	$KClO_3$ . .	0.0219	$\frac{1}{2}CuSO_4$.	0.0229	$\frac{1}{2}H_2SO_4$ . .	0.0125
$\frac{1}{2}MgCl_2$.	0.0241	$KC_2H_3O_2$.	0.0229	–	–	$\frac{1}{2}H_2SO_4$ for $m = .001$	0.0159

TABLE 282.

THE EQUIVALENT CONDUCTIVITY OF SALTS, ACIDS AND BASES IN AQUEOUS SOLUTIONS.

In the following table the equivalent conductance is expressed in reciprocal ohms. The concentration is expressed in milli-equivalents of solute per litre of solution at the temperature to which the conductance refers. (In the cases of potassium hydrogen sulphate and phosphoric acid the concentration is expressed in milli-formula-weights of solute, $KHSO_4$ or H_3PO_4, per litre of solution, and the values are correspondingly the modal, or "formal," conductances.) Except in the cases of the strong acids the conductance of the water was subtracted, and for sodium acetate, ammonium acetate and ammonium chloride the values have been corrected for the hydrolysis of the salts. The atomic weights used were those of the International Commission for 1905, referred to oxygen as 16.00. Temperatures are on the hydrogen gas scale.

$$\text{Concentration in } \frac{\text{gramme equivalents}}{\text{1000 litre}}.$$

$$\text{Equivalent conductance in } \frac{\text{reciprocal ohms per centimetre cube}}{\text{gramme equivalents per cubic centimetre}}.$$

Substance.	Concentration.	Equivalent conductance at the following ° C temperatures.									
		18°	25°	50°	75°	100°	128°	156°	218°	281°	306°
Potassium chloride .	0	130.1	(152.1)	(232.5)	(321.5)	414	(519)	625	825	1005	1120
" " .	2	126.3	146.4	–	–	393	–	588	779	930	1008
" " .	10	122.4	141.5	215.2	295.2	377	470	560	741	874	910
" " .	80	113.5	–	–	–	342	–	498	638	723	720
" " .	100	112.0	129.0	194.5	264.6	336	415	490			
Sodium chloride . .	0	109.0	–	–	–	362	–	555	760	970	1080
" " . .	2	105.6	–	–	–	349	–	534	722	895	955
" " . .	10	102.0	–	–	–	336	–	511	685	820	860
" " . .	80	93.5	–	–	–	301	–	450	500	674	680
" " . .	100	92.0	–	–	–	296	–	442			
Silver nitrate . . .	0	115.8	–	–	–	367	–	570	780	965	1065
" " . . .	2	112.2	–	–	–	353	–	539	727	877	935
" " . . .	10	108.0	–	–	–	337	–	507	673	790	818
" " . . .	20	105.1	–	–	–	326		488	639		
" " . . .	40	101.3	–	–	–	312	–	462	599	680	680
" " . . .	80	96.5	–	–	–	294	–	432	552	614	604
" " . . .	100	94.6	–	–	–	289					
Sodium acetate . .	0	78.1	–	–	–	285	–	450	660	–	924
" " . .	2	74.5	–	–	–	268	–	421	578	–	801
" " . .	10	71.2	–	–	–	253	–	396	542	–	702
" " . .	80	63.4	–	–	–	221	–	340	452		
Magnesium sulphate	0	114.1	–	–	–	426	–	690	1080		
" " .	2	94.3	–	–	–	302	–	377	260		
" " .	10	76.1	–	–	–	234	–	241	143		
" " .	20	67.5	–	–	–	190		195	110		
" " .	40	59.3	–	–	–	160	–	158	88		
" " .	80	52.0	–	–	–	136		133	75		
" " .	100	49.8	–	–	–	130	–	126			
" " .	200	43.1	–	–	–	110	–	109			
Ammonium chloride	0	131.1	152.0	–	–	(415)	–	(628)	(841)	–	(1176)
" " .	2	126.5	146.5	–	–	399	–	601	801	–	1031
" " .	10	122.5	141.7	–	–	382	–	573	758	–	925
" " .	30	118.1	–	–	–	–	–	–	–	–	828
Ammonium acetate .	0	(99.8)	–	–	–	(338)	–	(523)			
" " .	10	91.7	–	–	–	300	–	456			
" " .	25	88.2	–	–	–	286	–	426			

From the investigations of Noyes, Melcher, Cooper, Eastman and Kato; Journal of the American Chemical Society, 30, 1908.

THE EQUIVALENT CONDUCTIVITY OF SALTS, ACIDS AND BASES IN AQUEOUS SOLUTIONS.

Substance.	Concentration.	Equivalent conductance at the following ° C temperatures.									
		18°	25°	50°	75°	100°	128°	156°	218°	281°	306°
Barium nitrate . . .	0	116.9	–	–	–	385	–	600	840	1120	1300
“ “ . . .	2	109.7	–	–	–	352	–	536	715	828	824
“ “ . . .	10	101.0	–	–	–	322	–	481	618	658	615
“ “ . . .	40	88.7	–	–	–	280	–	412	507	503	448
“ “ . . .	80	81.6	–	–	–	258	–	372	449	430	
“ “ . . .	100	79.1	–	–	–	249					
Potassium sulphate .	0	132.8	–	–	–	455	–	715	1065	1460	1725
“ “ . .	2	124.8	–	–	–	402	–	605	806	893	867
“ “ . .	10	115.7	–	–	–	365	–	537	672	687	637
“ “ . .	40	104.2	–	–	–	320	–	455	545	519	466
“ “ . .	80	97.2	–	–	–	294	–	415	482	448	396
“ “ . .	100	95.0	–	–	–	286					
Hydrochloric acid .	0	379.0	–	–	–	850	–	1085	1265	1380	1424
“ “ . .	2	373.6	–	–	–	826	–	1048	1217	1332	1337
“ “ . .	10	368.1	–	–	–	807	–	1016	1168	1226	1162
“ “ . .	80	353.0	–	–	–	762	–	946	1044	1046	862
“ “ . .	100	350.6	–	–	–	754	–	929	1006		
Nitric acid	0	377.0	421.0	570	706	826	945	1047	(1230)	–	(1380)
“ “	2	371.2	413.7	559	690	806	919	1012	1166	–	1156
“ “	10	365.0	406.0	548	676	786	893	978			
“ “	50	353.7	393.3	528	649	750	845	917			
“ “	100	346.4	385.0	516	632	728	817	880	–	–	454*
Sulphuric acid . . .	0	383.0	(429)	(591)	(746)	891	(1041)	1176	1505	–	(2030)
“ “ . . .	2	353.9	390.8	501	561	571	551	536	563	–	637
“ “ . . .	10	309.0	337.0	406	435	446	460	481	533		
“ “ . . .	50	253.5	273.0	323	356	384	417	448	502		
“ “ . . .	100	233.3	251.2	300	336	369	404	435	483	–	474*
Potassium hydrogen sulphate . . .	2	455.3	506.0	661.0	754	784	773	754			
	50	295.5	318.3	374.4	403	422	446	477			
	100	263.7	283.1	329.1	354	375	402	435			
Phosphoric acid . .	0	338.3	376	510	631	730	839	930			
“ “ . .	2	283.1	311.9	401	464	498	508	489			
“ “ . .	10	203.0	222.0	273	300	308	298	274			
“ “ . .	50	122.7	132.6	157.8	168.6	168	158	142			
“ “ . .	100	96.5	104.0	122.7	129.9	128	120	108			
Acetic acid	0	(347.0)	–	–	–	(773)	–	(980)	(1165)	–	(1268)
“ “	10	14.50	–	–	–	25.1	–	22.2	14.7		
“ “	30	8.50	–	–	–	14.7	–	13.0	8.65		
“ “	80	5.22	–	–	–	9.05	–	8.00	5.34		
“ “	100	4.67	–	–	–	8.10	–	–	4.82	–	1.57
Sodium hydroxide .	0	216.5	–	–	–	594	–	835	1060		
“ “ . .	2	212.1	–	–	–	582	–	814			
“ “ . .	20	205.8	–	–	–	559	–	771	930		
“ “ . .	50	200.6	–	–	–	540	–	738	873		
Barium hydroxide .	0	222	256	389	(520)	645	(760)	847			
“ “ . . .	2	215	–	359	4	591					
“ “ . . .	10	207	235	342	449	548	664	722			
“ “ . . .	50	191.1	215.1	308	399	478	549	593			
“ “ . . .	100	180.1	204.2	291	373	443	503	531			
Ammonium hydroxide	0	(238)	(271)	(404)	(526)	(647)	(764)	(908)	(1141)	–	(1406)
	10	9.66	–	–	–	23.2	–	22.3	15.6		
	30	5.66	–	–	–	13.6	–	13.0			
	100	3.10	3.62	5.35	6.70	7.47	–	7.17	4.82	–	1.33

* These values are at the concentration 80.0.

TABLE 283.

THE EQUIVALENT CONDUCTIVITY OF SOME ADDITIONAL SALTS IN AQUEOUS SOLUTION.

Conditions similar to those of the preceding table except that the atomic weights for 1908 were used.

Substance.	Concentration.	Equivalent conductance at the following ° C temperature.							
		0°	18°	25°	50°	75°	100°	128°	156°
Potassium nitrate . . .	0	80.8	126.3	145.1	219	299	384	485	580
" " . . .	2	78.6	122.5	140.7	212.7	289.9	370.3	460.7	551
" " . . .	12.5	75.3	117.2	134.9	202.9	276.4	351.5	435.4	520.4
" " . . .	50	70.7	109.7	126.3	189.5	257.4	326.1	402.9	476.1
" " . . .	100	67.2	104.5	120.3	180.2	244.1	308.5	379.5	447.3
Potassium oxalate . . .	0	79.4	127.6	147.5	230	322	419	538	653
" " . . .	2	74.9	119.9	139.2	215.9	300.2	389.3	489.1	587
" " . . .	12.5	69.3	111.1	129.2	199.1	275.1	354.1	438.8	524.3
" " . . .	50	63	101	116.5	178.6	244.9	312.2	383.8	449.5
" " . . .	100	59.3	94.6	109.5	167	227.5	288.9	353.2	409.7
" " . . .	200	55.8	88.4	102.3	155	210.9	265.1	321.9	372.1
Calcium nitrate . . .	0	70.4	112.7	130.6	202	282	369	474	575
" " . . .	2	66.5	107.1	123.7	191.9	266.7	346.5	438.4	529.8
" " . . .	12.5	61.6	98.6	114.5	176.2	244	314.6	394.5	473.7
" " . . .	50	55.6	88.6	102.6	157.2	216.2	276.8	343	405.1
" " . . .	100	51.9	82.6	95.8	146.1	199.9	255.5	315.1	369.1
" " . . .	200	48.3	76.7	88.8	135.4	184.7	234.4	288	334.7
Potassium ferrocyanide .	0	98.4	159.6	185.5	288	403	527		
" " .	0.5	91.6	–	171.1					
" " .	2.	84.8	137	158.9	243.8	335.2	427.6		
" " .	12.5	71	113.4	131.6	200.3	271	340		
" " .	50	58.2	93.7	108.6	163.3	219.5	272.4		
" " .	100	53	84.9	98.4	148.1	198.1	245		
" " .	200	48.8	77.8	90.1	135.7	180.6	222.3		
" " .	400	45.4	72.1	83.3	124.8	165.7	203.1		
Barium ferrocyanide . .	0	91	150	176	277	393	521		
" " . .	2	46.9	75	86.2	127.5	166.2	202.3		
" " . .	12.5	30.4	48.8	56.5	83.1	107	129.8		
Calcium ferrocyanide .	0	88	146	171	271	386	512		
" " . .	2	47.1	75.5	86.2	130				
" " . .	12.5	31.2	49.9	57.4					
" " . .	50	24.1	38.5	44.4	64.6	81.9			
" " . .	100	21.9	35.1	40.2	58.4	73.7	84.3		
" " . .	200	20.6	32.9	37.8	55	68.7	77.5		
" " . .	400	20.2	32.2	37.1	54	67.5	76.2		
Potassium citrate . . .	0	76.4	124.6	144.5	228	320	420		
" " . . .	0.5	–	120.1	139.4					
" " . . .	2	71	115.4	134.5	210.1	293.8	381.2		
" " . . .	5	67.6	109.9	128.2	198.7	276.5	357.2		
" " . . .	12.5	62.9	101.8	118.7	183.6	254.2	326		
" " . . .	50	54.4	87.8	102.1	157.5	215.5	273		
" " . . .	100	50.2	80.8	93.9	143.7	196.5	247.5		
" " . . .	300	43.5	69.8	81	123.5	167	209.5		
Lanthanum nitrate . .	0	75.4	122.7	142.6	223	313	413	534	651
" " . .	2	68.9	110.8	128.9	200.5	279.8	363.5	457.5	549
" " . .	12.5	61.4	98.5	114.4	176.7	243.4	311.2	383.4	447.8
" " . .	50	54	86.1	99.7	152.5	207.6	261.4	315.8	357.7
" " . .	100	49.9	79.4	91.8	139.5	189.1	236.7	282.5	316.3
" " . .	200	46	72.1	83.5	126.4	170.2	210.8	249.6	276.2

From the investigations of Noyes and Johnston, Journal of the American Chemical Society, 31, 1909.

CONDUCTANCE OF IONS. — HYDROLYSIS OF AMMONIUM ACETATE.

TABLE 284. — The Equivalent Conductance of the Separate Ions.

Ion.	0°	18°	25°	50°	75°	100°	128°	156°
K	40.4	64.6	74.5	115	159	206	263	317
Na	26	43.5	50.9	82	116	155	203	249
NH_4	40.2	64.5	74.5	115	159	207	264	319
Ag	32.9	54.3	63.5	101	143	188	245	299
$\frac{1}{2}$Ba	33	55[2]	65	104	149	200	262	322
$\frac{1}{2}$Ca	30	51[2]	60	98	142	191	252	312
$\frac{1}{3}$La	35	61	72	119	173	235	312	388
Cl	41.1	65.5	75.5	116	160	207	264	318
NO_3	40.4	61.7	70.6	104	140	178	222	263
$C_2H_3O_2$	20.3	34.6	40.8	67	96	130	171	211
$\frac{1}{2}SO_4$	41	68[2]	79	125	177	234	303	370
$\frac{1}{2}C_2O_4$	39	63[2]	73	115	163	213	275	336
$\frac{1}{3}C_6H_5O_7$	36	60	70	113	161	214		
$\frac{1}{4}Fe(CN)_6$	58	95	111	173	244	321		
H	240	314	350	465	565	644	722	777
OH	105	172	192	284	360	439	525	592

From Johnson, Journ. Amer. Chem. Soc., 31, 1909.

TABLE 285. — Hydrolysis of Ammonium Acetate and Ionization of Water.

Temperature.	Percentage hydrolysis.	Ionization constant of water.	Hydrogen-ion concentration in pure water. Equivalents per litre.
t	100h	$K_W \times 10^{14}$	$C_H \times 10^7$
0	–	0.089	0.30
18	(0.35)	0.46	0.68
25	–	0.82	0.91
100	4.8	48.	6.9
156	18.6	223.	14.9
218	52.7	461.	21.5
306	91.5	168.	13.0

Noyes, Kato, Kanolt, Sosman, No. 63 Publ. Carnegie Inst., Washington.

DIELECTRIC CONSTANTS.

TABLE 286.—Dielectric Constant (Specific Inductive Capacity) of Gases. Atmospheric Pressure.

Wave-lengths of the measuring current greater than 10000 cm.

Gas.	Temp. °C.	Dielectric constant referred to		Authority.
		Vacuum=1	Air=1	
Air	0	1.000590	1.000000	Boltzmann, 1875.
"	–	1.000586	1.000000	Klemenčič, 1885.
Ammonia	20	1.00718	1.00659	Bädeker, 1901.
Carbon bisulphide	0	1.00290	1.00231	Klemenčič.
" "	100	1.00239	1.00180	Bädeker.
Carbon dioxide	0	1.000946	1.000356	Boltzmann.
" "	0	1.000985	1.000399	Klemenčič.
Carbon monoxide	0	1.000690	1.000100	Boltzmann.
" "	0	1.000695	1.000109	Klemenčič.
Ethylene	0	1.00131	1.00072	Boltzmann.
"	0	1.00146	1.00087	Klemenčič.
Hydrochloric acid	100	1.00258	1.00199	Bädeker.
Hydrogen	0	1.000264	0.999674	Boltzmann.
"	0	1.000264	0.999678	Klemenčič.
Methane	0	1.000944	1.000354	Boltzmann.
"	0	1.000953	1.000367	Klemenčič.
Nitrous oxide (N_2O)	0	1.00116	1.00057	Boltzmann.
" " "	0	1.00099	1.00041	Klemenčič.
Sulphur dioxide	0	1.00993	1.00934	Bädeker.
" "	0	1.00905	1.00846	Klemenčič.
Water vapor, 4 atmospheres	145	1.00705	1.00646	Bädeker.

TABLE 287.—Variation of the Dielectric Constant with the Temperature.

For variation with the pressure see next table.

If D_θ = the dielectric constant at the temperature θ° C., D_t at the temperature t° C., and α and β are quantities given in the following table, then

$$D_\theta = D_t\,[1 - \alpha(t-\theta) + \beta(t-\theta)^2].$$

The temperature coefficients are due to Bädeker.

Gas.	α	β	Range of temp. °C.
Ammonia	5.45×10^{-6}	2.59×10^{-7}	10 — 110
Sulphur dioxide	6.19×10^{-6}	1.86×10^{-7}	0 — 110
Water vapor	1.4×10^{-4}	–	145

The dielectric constant of air at atmospheric pressure but with varying temperature may also be calculated from the fact that $D - 1$ is approximately proportional to the density.

DIELECTRIC CONSTANTS (*continued*).

TABLE 288.—Change of the Dielectric Constant of Gases with the Pressure.

Gas.	Temperature, ° C.	Pressure atmos.	Dielectric constant.	Authority.
Air	19	20	1.0108	Tangl, 1907.
“	–	40	1.0218	“ “
“	–	60	1.0330	“ “
“	–	80	1.0439	“ “
“	–	100	1.0548	“ “
“	11	20	1.0101	Occhialini, 1905.
“	–	40	1.0196	“ “
“	–	60	1.0294	“ “
“	–	80	1.0387	“ “
“	–	100	1.0482	“ “
“	–	120	1.0579	“ “
“	–	140	1.0674	“ “
“	–	160	1.0760	“ “
“	–	180	1.0845	“ “
Carbon dioxide . .	15	10	1.008	Linde, 1895.
“ “ . .	–	20	1.020	“ “
“ “ . .	–	40	1.060	“ “
Nitrous oxide, N_2O	15	10	1.010	“
“ “ “	–	20	1.025	“
“ “ “	–	40	1.070	“

TABLE 288.—Dielectric Constants of Liquids.

A wave-length greater than 10000 centimetres is denoted by ∞.

Substance.	Temp. ° C.	Wave-length, cm.	Dielectric constant.	Authority.	Substance.	Temp. ° C.	Wave-length, cm.	Dielectric constant.	Authority.
Alcohol:					Alcohol:				
Amyl . . .	frozen	∞	2.4	1	Methyl . .	—50	∞	45.3	1
“ . . .	—100	“	30.1	1	“ . . .	0	“	35.0	1
“ . . .	—50	“	23.0	1	“ . . .	+20	“	31.2	1
“ . . .	0	“	17.4	1	“ . . .	17	75	33.2	2
“ . . .	+20	“	16.0	1	Propyl . .	—120	∞	46.2	1
“ . . .	18	200	10.8	2	“ . . .	—60	“	33.7	1
“ . . .	18	73	4.7	2	“ . . .	0	“	24.8	1
Ethyl . . .	frozen	∞	2.7	1	“ . . .	+20	“	22.2	1
“ . . .	—120	“	54.6	1	“ . . .	15	75	12.3	2
“ . . .	—80	“	44.3	1	Acetone . . .	—80	∞	33.8	5
“ . . .	—40	“	35.3	1	“ . . .	0	“	26.6	5
“ . . .	0	“	28.4	1	“ . . .	15	1200	21.85	6
“ . . .	+20	“	25.8	1	“ . . .	17	73	20.7	7
“ . . .	17	200	24.4	2	Acetic acid .	18	∞	9.7	8
“ . . .	“	75	23.0	2	“ “ . .	15	1200	10.3	6
“ . . .	“	53	20.6	3	“ “ . .	17	200	7.07	2
“ . . .	“	4	8.8	3	“ “ . .	19	75	6.29	2
“ . . .	“	0.4	5.0	4	Amyl acetate .	19	∞	4.81	9
Methyl . .	frozen	∞	3.07	1	Amylene . .	16	“	2.20	10
“ . . .	—100	“	58.0	1					

References on page 281.

TABLE 289 (*continued*).

DIELECTRIC CONSTANTS OF LIQUIDS.

A wave-length greater than 10000 centimetres is desiguated by ∞.

Substance.	Temp. °C.	Wave-length cm.	Diel. const.	Authority.
Anilin	18	∞	7.316	11
Benzol (benzene) .	18	"	2.288	"
" " .	19	73	2.26	2
Bromine	23	84	3.18	12
Carbon bisulphide	20	∞	2.626	13
" " .	17	73	2.64	2
Chloroform . . .	18	∞	5.2	11
" . . .	17	73	4.95	2
Decane	14	∞	1.97	10
Decylene . . .	17	"	2.24	"
Ethyl ether . .	—80	∞	7.05	5
" " . . .	—40	"	5.67	"
" " . . .	0	"	4.68	"
" " . . .	18	"	4.368	11
" " . . .	20	"	4.30	13
" " . . .	60	"	3.65	"
" " . . .	100	"	3.12	"
" " . . .	140	"	2.66	"
" " . . .	180	"	2.12	"
" " . . .	Crit. temp. 192	"	1.53	"
" " . . .	18	83	4.35	14
Formic acid . .	+2	73	19.0	2
" " . . .	(frozen) 15	1200	62.0	6
" " . . .	16	73	58.5	2
Glycerine . . .	15	1200	56.2	6
"	15	200	39.1	2
"	15	75	25.4	"
"	–	8.5	4.4	15
"	–	0.4	2.6	4
Hexane	17	∞	1.880	16
Hydrogen peroxide 46 % in H_2O	18	75	84.7	17

Substance.	Temp. °C.	Wave-length cm.	Diel. const.	Authority.
Nitrobenzol . . .	(frozen) —10	∞	9.9	1
" . . .	—5	"	42.0	"
" . . .	0	"	41.0	"
" . . .	+15	"	37.8	"
" . . .	30	"	35.1	"
" . . .	18	"	36.45	11
" . . .	17	73	34.0	2
Octane	17	∞	1.949	16
Oils :				
Almond . . .	20	∞	2.83	18
Castor	11	"	4.67	19
Colza	20	"	3.11	20
Cottonseed . .	14	"	3.10	21
Lemon	21	"	2.25	22
Linseed . . .	13	"	3.35	21
Neatsfoot . . .	–	"	3.02	20
Olive	20	"	3.11	23
Peanut	11.4	"	3.03	21
Petroleum . .	–	2000	2.13	24
Petroleum ether	20	∞	1.92	20
Rape seed . .	16	"	2.85	21
Sesame . . .	13.4	"	3.02	"
Sperm	20	"	3.17	20
Turpentine . .	20	"	2.23	"
Vaseline . . .	–	"	2.17	25
Phenol	48	73	9.68	2
Toluol	—83	∞	2.51	5
"	+16	"	2.33	"
"	19	73	2.31	2
Meta-xylol . . .	18	∞	2.37^6	11
" " . . .	17	73	2.37	2
Water	18	∞	81.07	11
for temp. coeff.	17	200	80.6	2
see Table.	17	74	81.7	"
	17	38	83.6	"

1 Abegg-Seitz, 1899.
2 Drude, 1896.
3 Marx, 1898.
4 Lampa, 1896.
5 Abegg, 1897.
6 Thwing, 1894.
7 Drude, 1898.
8 Francke, 1893.
9 Löwe, 1898.
10 Landolt-Jahn, 1892.
11 Turner, 1900.
12 Schlundt.
13 Tangl, 1903.
14 Coolidge, 1899.
15 v. Lang, 1896.
16 Nernst, 1894.
17 Calvert, 1900.
18 Hasenöhrl, 1896.
19 Arons-Rubens, 1892.
20 Hopkinson, 1881.
21 Salvioni, 1888.
22 Tomaszewski, 1888.
23 Heinke, 1896.
24 Marx.
25 Fuchs.

DIELECTRIC CONSTANTS OF LIQUIDS (*continued*).

TABLE 290.—Temperature Coefficients of the Formula:

$$D_\theta = D_t[1 - a(t-\theta) + \beta(t-\theta)^2].$$

Substance.	a	β	Temp. range, ° C.	Authority.
Amyl acetate . . .	0.0024	–	–	Löwe.
Aniline	0.00351	–	–	Ratz.
Benzol	0.00106	0.0000087	10–40	Hasenöhrl.
Carbon bisulphide .	0.000966	–	–	Ratz.
" " .	0.000922	0.00000060	20–181	Tangl.
Chloroform . . .	0.00410	0.0000015	22–181	"
Ethyl ether . . .	0.00459	–	–	Ratz.
Methyl alcohol . .	0.0057	–	–	Drude.
Oils: Almond . .	0.00163	0.000026	–	Hasenöhrl.
Castor . . .	0.01067	–	–	Heinke, 1896.
Olive . . .	0.00364	–	–	" "
Paraffine . .	0.000738	0.0000072	–	Hasenöhrl.
Toluol	0.000921	–	0–13	Ratz.
"	0.000977	0.00000046	20–181	Tangl.
Water	0.004474	–	5–20	Heerwagen.
"	0.004583	0.0000117	0–76	Drude.
"	0.00436	–	4–25	Coolidge.
Meta-xylol . . .	0.000817	–	20–181	Tangl.

(See Table 287 for the signification of the letters.)

TABLE 291.—Dielectric Constants of Liquified Gases.

A wave-length greater than 10000 centimetres is designated by ∞.

Substance.	Temp. ° C.	Wave-length cm.	Dial. constant.	Authority.	Substance.	Temp. ° C.	Wave-length cm.	Dial. constant.	Authority.
Air	—191	∞	1.432	1	Nitrous oxide				
"	"	75	1.47–1.50	2	N_2O	—88	∞	1.938	8
Ammonia . . .	—34	75	21–23	3	" " .	—5	"	1.630	5
"	14	130	16.2	4	" " .	+5	"	1.578	"
Carbon dioxide .	—5	∞	1.608	5	" " .	+15	"	1.520	"
" " .	0	"	1.588	"	Oxygen . . .	—182	"	1.491	9
" " .	+10	"	1.540	"	" . . .	"	"	1.465	8
" " .	+15	"	1.528	"	Sulphur dioxide .	14.5	120	13.75	4
Chlorine . . .	—60	"	2.150	"	" " .	20	∞	14.0	6
" . . .	—20	"	2.030	"	" " .	40	"	12.5	"
" . . .	0	"	1.970	"	" " .	60	"	10.8	"
" . . .	+10	"	1.940	"	" " .	80	"	9.2	"
" . . .	0	"	2.08	6	" " .	100	"	7.8	"
" . . .	+14	100	1.88	4	" " .	120	"	6.4	"
Cyanogen . . .	23	84	2.52	7	" " .	140	"	4.8	"
Hydrocyanic acid	21	"	about 95	"	Critical	154.2	"	2.1	"
Hydrogen sulph.	10	∞	5.93	6					
" " .	50	"	4.92	"					
" " .	90	"	3.76	"					

1 v. Pirani, 1903.
2 Bahn-Kiebitz, 1904.
3 Goodwin-Thompson, 1899.
4 Coolidge, 1899.
5 Linde, 1895.
6 Eversheim, 1904.[1]
7 Schlundt, 1901.
8 Hasenöhrl, 1900.
9 Fleming-Dewar, 1896.

TABLE 292.—Standard Solutions for the Calibration of Apparatus for the Measuring of Dielectric Constants.

Turner.

Substance.	Diel. const. at 18°. λ = ∞.
Benzol	2.288
Meta-xylol	2.376
Ethyl ether	4.36^7
Aniline	7.29^8
Ethyl chloride . . .	10.90
O-nitro toluol . . .	27.71
Nitrobenzol	36.45
Water (conduct. 10^{-6})	81.07

Drude.

Acetone in benzol at 19°. λ = 75 cm.			
Per cent by weight.	**Density 16°.**	**Dielectric constant.**	**Temp. coefficient.**
0	0.885	2.26	0.1%
20	0.866	5.10	0.3
40	0.847	8.43	0.4
60	0.830	12.1	0.5
80	0.813	16.2	0.5
100	0.797	20.5	0.6

Water in acetone at 19°. λ = 75 cm.			
Per cent by weight.	**Density 16°.**	**Dielectric constant.**	**Temp. coefficient.**
0	0.797	20.5	0.6%
20	0.856	31.5	0.5
40	0.903	43.5	0.5
60	0.940	57.0	0.5
80	0.973	70.6	0.
100	0.999	80.9	0.4

Nernst.

Ethyl alcohol in water at 19.5°. λ = ∞.	
Per cent by weight.	**Dielectric constant.**
100	26.0
90	29.3
80	33.5
70	38.0
60	43.1

TABLE 293.—Dielectric Constants of Solids.

Substance.	Condition.	Wave-length, cm.	Dielectric constant.	Authority.
Asphalt . .	–	∞	2.68	1
Barium sulphate . .	–	75	10.2	2
Caoutchouc .	–	∞	2.22	3
Diamond . .	–	"	16.5	1
" . .	–	75	5.50	2
Ebonite . .	–	∞	2.72	4
" . .	–	"	2.86	5
" . .	–	1000	2.55	6
Glass *	Density.			
Flint (extra heavy) .	4.5	∞	9.90	7
Flint (very light) . .	2.87	"	6.61	7
Hard crown	2.48	"	6.96	7
Mirror . .	–	"	6.44–7.46	5
" . .	–	"	5.37–5.90	8
" . .	–	600	5.42–6.20	8
Lead (Powell) . . .	3.0–3.5	∞	5.4–8.0	9
Jena				
Boron .	–	"	5.5–8.1	10
Barium .	–	"	7.8–8.5	10
Borosilicate .	–	"	6.4–7.7	1
Gutta percha .	–	–	3.3–4.9	11
	Temp.			
Ice	—5	1200	2.85	12
"	—18	5000	3.16	13
"	—190	75	1.76–1.88	14

Substance.	Condition.	Wave-length, cm.	Dielectric constant.	Authority.
	Temp.			
Iodine (cryst.) .	23	75	4.00	2
Lead chloride . (powder)	–	"	42	2
" nitrate .	–	"	16	2
" sulphate .	–	"	28	2
" molybdenate . .	–	"	24	2
Marble (Carrara)	–	"	8.3	2
Mica	–	∞	5.66–5.97	5
"	–	"	5.80–6.62	15
Madras, brown	–	"	2.5–3.4	16
" green	–	"	3.9–5.5	16
" ruby .	–	"	4.4	16
Bengal, yellow	–	"	2.8	16
" white .	–	"	4.2	16
" ruby .	–	"	4.2–4.7	16
Canadian amber	–	"	3.0	16
South America	–	"	5.9	16
Ozokerite (raw)	–	"	2.21	1
Paper (telephone)	–	"	2.0	17
" (cable) .	–	"	2.0–2.5	1
Paraffine . . .		"	2.46	18
" . . .	Melting point.	"	2.32	19
" . . .	44–46	"	2.10	20
" . . .	54–56	"	2.14	20
" . . .	74–76	"	2.16	20

References on p. 284.

* For the effect of temperature, see Gray-Dobbie, Pr. Roy. Soc. 63, 1898; 67, 1900.
" " " " wave-length, see K. F. Löwe, Wied. Ann. 66, 1898.

DIELECTRIC CONSTANTS (*continued*).

TABLE 293. — Dielectric Constants of Solids (*continued*).

Substance.	Condition.	Wave-length, cm.	Diel. constant.	Authority.
Paraffine	47.°06	61	2.16	21
"	56.°2	61	2.25	21
Phosphorus:				
Yellow	–	75	3.60	2
Solid	–	80	4.1	22
Liquid	–	80	3.85	22
Porcelain:				
Hard (Royal B'l'n)	–	∞	5.73	15
Seger " "	–	"	6.61	15
Figure " "	–	"	6.84	15
Selenium	–	"	7.44	1
"	–	75	6.60	2
"	–	∞	6.13	23
"	–	1000	6.14	23
Shellac	–	∞	3.10	4
"	–	"	2.95–3.73	24
"	–	"	3.67	25
Sulphur				
Amorphous	–	∞	3.98	1
"	–	75	3.80	2
Cast, fresh	–	∞	4.22	1
" "	–	"	4.05	18
" "	–	75	3.95	2
Cast, old	–	∞	3.60	18
" "	–	75	3.90	2
Liquid	near melting-point	∞	3.42	1
Strontium sulphate	–	75	11.3	2
Thallium carbonate	–	75	17	2
" nitrate	–	75	16.5	2
Wood			dried	
Red beech	‖ fibres	∞	4.83–2.51	–
" "	⊥ "	"	7.73–3.63	–
Oak	‖ "	"	4.22–2.46	–
"	⊥ "	"	6.84–3.64	–

1 v. Pirani, 1903.
2 Schmidt, 1903.
3 Gordon, 1879.
4 Winklemann, 1889.
5 Elsas, 1891.
6 Ferry, 1897.
7 Hopkinson, 1891.
8 Arons-Rubens, 1891.
9 Gray-Dobbie, 1898.
10 Löwe, 1898.
11 (submarine-data).
12 Thwing, 1894.
13 Abegg, 1897.
14 Behn-Kiebitz, 1904.
15 Starke, 1897.
16 E. Wilson.
17 Campbell, 1906.
18 Fallinger, 1902.
19 Boltzmann, 1875.
20 Zietkowski, 1900.
21 Hormell, 1902.
22 Schlundt, 1904.
23 Vonwiller-Mason, 1907.
24 Wüllner, 1887.
25 Donle.

TABLE 294. — Dielectric Constants of Crystals.

Dα, Dβ, Dγ are the dielectric constants along the brachy, macro and vertical axes respectively.

Substance.	Wave-length, cm.	Diel. const.		Authority.
		⊥ Axis.	‖ Axis.	
UNIAXIAL:				
Apatite	75	9.50	7.40	1
Beryl	∞	7.85	7.44	2
"	"	7.10	6.05	3
"	75	6.05	5.52	1
Calcspar	∞	8.49	7.56	4
"	"	8.78	8.29	5
Dolomite	75	7.80	6.80	1
Iceland spar	75	8.50	8.00	1
Quartz	∞	4.69	5.06	4
"	"	4.38	4.46	6
"	1000	4.27	4.34	6
"	75	4.32	4.60	1
Rutil (TiO_2)	75	89	173	1
Tourmaline	∞	7.13	6.54	4
"	75	6.75	5.65	1
Zircon	75	12.8	12.6	1

Substance.	Wave-length, cm.	Diel. coost.			Authority.
		Dα	Dβ	Dγ	
RHOMBIC:					
Arragonite	∞	9.14	–	7.13	4
"	75	9.80	7.68	6.55	1
Barite	∞	6.97	10.09	7.00	4
"	75	7.65	12.20	7.70	1
Cœlestin	75	7.70	18.5	8.30	1
Cerussite	75	25.4	23.2	19.2	1
$MgSO_4 + 7H_2O$	∞	5.26	6.05	8.28	7
K_2SO_4	"	6.09	5.08	4.48	7
Rochelle salt	"	6.70	6.92	8.89	7
Sulphur	"	3.81	3.97	4.77	8
"	"	3.65	3.85	4.66	7
"	75	3.62	3.85	4.66	1
Topaz	75	6.65	6.70	6.30	1

1 Schmidt, 1903.
2 Starke, 1897.
3 Curie, 1889.
4 Fallinger, 1902.
5 v. Pirani, 1903.
6 Ferry, 1897.
7 Borel, 1893.
8 Boltzmann, 1875.

TABLE 295.

VARIATION OF ELECTRICAL RESISTANCE OF GLASS AND PORCELAIN WITH TEMPERATURE.

The following table gives the values of *a*, *b*, and *c* in the equation

$$\log R = a + bt + ct^2,$$

where R is the specific resistance expressed in ohms, that is, the resistance in ohms per centimetre of a rod one square centimetre in cross section.*

No.	Kind of glass.	Density.	*a*	*b*	*c*	Range of temp. Centigrade.
1	Test-tube glass	–	13.86	—.044	.000065	0°–250°
2	" " "	2.458	14.24	—.055	.0001	37–131
3	Bohemian glass	2.43	16.21	—.043	.0000394	60–174
4	Lime glass (Japanese manufacture) .	2.55	13.14	—.031	—.000021	10–85
5	" " " " .	2.499	14.002	—.025	—.00006	35–95
6	Soda-lime glass (French flask) .	2.533	14.58	—.049	.000075	45–120
7	Potash-soda lime glass . . .	2.58	16.34	—.0425	.0000364	66–193
8	Arsenic enamel flint glass . .	3.07	18.17	—.055	.000088	105–135
9	Flint glass (Thomson's electrometer jar)	3.172	18.021	—.036	—.0000091	100–200
10	Porcelain (white evaporating dish) .	–	15.65	—.042	.00005	68–290

COMPOSITION OF SOME OF THE ABOVE SPECIMENS OF GLASS.

Number of specimen =	3	4	5	7	8	9
Silica	61.3	57.2	70.05	75.65	54.2	55.18
Potash	22.9	21.1	1.44	7.92	10.5	13.28
Soda	Lime, etc.	Lime, etc.	14.32	6.92	7.0	–
Lead oxide	by diff.	by diff.	2.70	–	23.9	31.01
Lime	15.8	16.7	10.33	8.48	0.3	0.35
Magnesia	–	–	–	0.36	0.2	0.06
Arsenic oxide . . .	–	–	–	–	3.5	–
Alumina, iron oxide, etc. .	–	–	1.45	0.70	0.4	0.67

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* T. Gray, "Phil. Mag." 1880, and "Proc. Roy. Soc." 1882.

PERMEABILITY OF IRON.

TABLE 296.—Permeability of Iron Rings and Wire.

This table gives, for a few specimens of iron, the magnetic induction B, and permeability μ, corresponding to the magneto-motive forces H recorded in the first column. The first specimen is taken from a paper by Rowland,[*] and refers to a welded and annealed ring of "Burden's Best" wrought iron. The ring was 6.77 cms. in mean diameter, and the bar had a cross sectional area of 0.916 sq. cms. Specimens 2–4 are taken from a paper by Bosanquet,[†] and also refers to soft iron rings. The mean diameters were 21.5, 22.1, and 22.725 cms., and the thickness of the bars 2.535, 1.295, and .7544 cms. respectively. These experiments were intended to illustrate the effect of thickness of bar on the induction. Specimen 5 is from Ewing's book,[‡] and refers to one of his own experiments on a soft iron wire .077 cms. diameter and 30.5 cms. long.

H	Specimen 1		2		3		4		5	
	B	μ	B	μ	B	μ	B	μ	B	μ
0.2	80	400	126	630	65	325	85	425	22	110
0.5	330	660	377	754	224	448	214	428	74	148
1.0	1450	1450	1449	1449	840	840	885	885	246	246
2.0	4840	2420	4564	2282	3533	1766	2417	1208	950	475
5.0	9880	1976	9900	1980	8293	1659	8884	1777	12430	2486
10.0	12970	1297	13023	1302	12540	1254	11388	1139	15020	1502
20.0	14740	737	14911	746	14710	735	13273	664	15790	789
50.0	16390	328	16217	324	16062	321	13890	278	–	–
100.0	–	–	17148	171	17900	179	14837	148	–	–

NOTE.—The comparatively high value of the magnetizing force required for maximum permeability when the specimen is a thin drawn wire is noticeable in specimen 5.

TABLE 297.—Permeability of Transformer Iron.[§]

This table contains the results of some experiments on transformers of the Westinghouse and Thomson-Houston types. Referring to the headings of the different columns, M is the total magneto-motive force applied to the iron; M/l the magneto-motive force per centimetre length of the iron circuit; B the total induction through the magnetizing coil; B/a the induction per square centimetre of the mean section of the iron core; M/B the magnetic reluctance of the iron circuit; Bl/Ma the permeability of the iron, a being taken as the mean cross section of the iron circuit as it exists in the transformer, which is thus slightly greater than the actual cross section of the iron.

(a) WESTINGHOUSE No. 8 TRANSFORMERS (ABOUT 2500 WATTS CAPACITY).

M	$\frac{M}{l}$	First specimen.				Second specimen.			
		B	$\frac{B}{a}$	$\frac{M}{B}$	$\frac{Bl}{Ma}$	B	$\frac{B}{a}$	$\frac{M}{B}$	$\frac{Bl}{Ma}$
20	0.597	218×10^8	1406	0.917×10^{-4}	2360	16×10^4	1032	1.25×10^{-4}	1730
40	1.194	587 “	3790	0.681 “	3120	49 “	3140	0.82 “	2640
60	1.791	878 “	5660	0.683 “	3180	82 “	5290	0.73 “	2970
80	2.338	1091 “	7040	0.734 “	2960	104 “	6710	0.77 “	2820
100	2.985	1219 “	7860	0.819 “	2640	118 “	7610	0.85 “	2560
120	3.582	1330 “	8580	0.903 “	2410	124 “	8000	0.97 “	2250
140	4.179	1405 “	9060	0.994 “	2186	131 “	8450	1.07 “	2036
160	4.776	1475 “	9510	1.090 “	2000	135 “	8710	1.18 “	1830
180	5.373	1532 “	9880	1.180 “	1850	140 “	9030	1.29 “	1690
200	5.970	1581 “	10200	1.270 “	1720	142 “	9160	1.41 “	1540
220	6.567	1618 “	10430	1.360 “	1590	144 “	9290	1.53 “	1410
260	7.761	1692 “	10910	1.540 “	1410	–	–	–	–

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[*] "Phil. Mag." 4th series, vol. xlv. p. 151.

[†] Ibid. 5th series, vol. xix. p. 73.

[‡] "Magnetic Induction in Iron and Other Metals."

[§] T. Gray, from special experiments.

PERMEABILITY OF TRANSFORMER IRON.

(b) WESTINGHOUSE No. 6 TRANSFORMERS (ABOUT 1800 WATTS CAPACITY).

M	$\frac{M}{l}$	First specimen.				Second specimen.			
		B	$\frac{B}{a}$	$\frac{M}{B}$	$\frac{Bl}{Ma}$	B	$\frac{B}{a}$	$\frac{M}{B}$	$\frac{Bl}{Ma}$
20	0.62	147×10^8	1320	1.36×10^{-4}	2140	215×10^8	1940	0.93×10^{-4}	3140
40	1.23	442 "	3980	0.91 "	3260	615 "	5540	0.64 "	4490
60	1.85	697 "	6280	0.86 "	3390	826 "	7440	0.72 "	4030
80	2.46	862 "	7770	0.93 "	3140	986 "	8880	0.81 "	3590
100	3.08	949 "	8550	1.05 "	2770	1050 "	9460	0.95 "	3060
120	3.70	1010 "	9106	1.19 "	2450	1100 "	9910	1.09 "	2670
140	4.31	1060 "	9550	1.33 "	2210	1140 "	10300	1.23 "	2430
160	4.93	1090 "	9820	1.47 "	1990	1170 "	10500	1.37 "	2180
180	5.55	1120 "	10100	1.61 "	1830	1190 "	10700	1.51 "	1970
200	6.16	1150 "	10400	1.74 "	1680	–	–	–	–

(c) WESTINGHOUSE No. 4 TRANSFORMER (ABOUT 1200 WATTS CAPACITY).

M	$\frac{M}{l}$	B	$\frac{B}{a}$	$\frac{M}{B}$	$\frac{Bl}{Ma}$
20	0.69	147×10^8	1470	1.36×10^{-4}	2140
40	1.38	406 "	4066	0.98 "	2940
60	2.07	573 "	5730	1.05 "	2770
80	2.76	659 "	6590	1.21 "	2390
100	3.45	714 "	7140	1.40 "	2070
120	4.14	748 "	7490	1.60 "	1810
140	4.83	777 "	7770	1.80 "	1610

(d) THOMSON-HOUSTON 1500 WATTS TRANSFORMER.

M	$\frac{M}{l}$	B	$\frac{B}{a}$	$\frac{M}{B}$	$\frac{Bl}{Ma}$
20	0.42	70×10^8	1560	2.86×10^{-4}	3730
40	0.84	142 "	3160	2.81 "	3780
60	1.26	214 "	4770	2.81 "	3790
80	1.68	265 "	5910	3.02 "	3520
100	2.10	309 "	6890	3.24 "	3280
120	2.52	348 "	7760	3.45 "	3080
160	3.36	408 "	9100	3.92 "	2710
200	4.20	456 "	10200	4.39 "	2430
240	5.04	495 "	11000	4.87 "	2190
280	5.88	524 "	11690	5.35 "	1990
320	6.72	550 "	12270	5.82 "	1820
360	7.56	573 "	12780	6.29 "	1690
400	8.40	591 "	13180	6.78 "	1570
440	9.24	504 "	13470	7.28 "	1460

TABLE 298. — Magnetic Properties of Iron and Steel.

		Electrolytic Iron.	Good Cast Steel.	Poor Cast Steel.	Steel.	Cast Iron.	Electrical Sheets.	
							Ordinary.	Silicon Steel.
Chemical composition in per cent	C	0.024	0.044	0.56	0.99	3.11	0.036	0.036
	Si	0.004	0.004	0.18	0.10	3.27	0.330	3.90
	Mn	0.008	0.40	0.29	0.40	0.56	0.260	0.090
	P	0.008	0.044	0.076	0.04	1.05	0.040	0.009
	S	0.001	0.027	0.035	0.07	0.06	0.068	0.006
Coercive force . . .		2.83 [0.36]	1.51 [0.37]	7.1 (44.3)	16.7 (52.4)	11.4 [4.6]	[1.30]	[0.77]
Residual B		11400 [10800]	10600 [11000]	10500 (10500)	13000 (7500)	5100 [5350]	[9400]	[9850]
Maximum permeability		1850 [14400]	3550 [14800]	700 (170)	375 (110)	240 [600]	[3270]	[6130]
B for H=150 . . .		19200 [18900]	18800 [19100]	17400 (15400)	16700 (11700)	10400 [11000]	[18200]	[17550]
$4\pi I$ for saturation .		21620 [21630]	21420 [21420]	20600 (20200)	19800 (18000)	16400 [16800]	[20500]	[19260]

E. Gumlich, Zs. für Electrochemie, 15, p. 599; 1909.

Brackets indicate annealing at 800° C in vacuum. *Parentheses* indicate hardening by quenching from cherry-red.

TABLE 299. — Cast Iron in Intense Fields.

Soft Cast Iron.				Hard Cast Iron.			
H	B	I	μ	H	B	I	μ
114	9950	782	87.3	142	7860	614	55.4
172	10800	846	62.8	254	9700	752	38.2
433	13900	1070	32.1	339	10850	836	30.6
744	15750	1200	21.2	684	13050	983	19.1
1234	17300	1280	14.0	915	14050	1044	15.4
1820	18170	1300	10.0	1570	15900	1138	10.1
12700	31100	1465	2.5	2020	16800	1146	8.3
13550	32100	1475	2.4	10900	26540	1235	2.4
13800	32500	1488	2.4	13200	28600	1226	2.2
15100	33650	1472	2.2	14800	30200	1226	2.0

B. O. Peirce, Proc. Am. Acad. 44, 1909.

TABLE 300. — Corrections for Ring Specimens.

In the case of ring specimens, the average magnetizing force is not the value at the mean radius, the ratio of the two being given in the table. The flux density consequently is not uniform, and the measured hysteresis is less than it would be for a uniform distribution. This ratio is also given for the case of constant permeability, the values being applicable for magnetizations in the neighborhood of the maximum permeability. For higher magnetizations the flux density is more uniform, for lower it is less, and the correction greater.

Ratio of Radial Width to Diameter of Ring.	Ratio of Average H to H at Mean Radius.		Ratio of Hysteresis for Uniform Distribution to Actual Hysteresis.	
	Rectangular Cross-section.	Circular Cross-section.	Rectangular Cross-section.	Circular Cross-section.
1/2	1.0986	1.0718	1.112	1.084
1/3	1.0397	1.0294	1.045	1.033
1/4	1.0216	1.0162	1.024	1.018
1/5	1.0137	1.0102	1.015	1.011
1/6	1.0094	1.0070	1.010	1.008
1/7	1.0069	1.0052	1.008	1.006
1/8	1.0052	1.0040	1.006	1.004
1/10	1.0033	1.0025	1.003	1.002
1/19	1.0009	1.0007	1.001	1.001

M. G. Lloyd, Bull. Bur. Standards, 5, p. 435; 1908.

DEMAGNETIZING FACTORS FOR RODS.

TABLE 301.

H = true intensity of magnetizing field, H' = intensity of applied field, I = intensity of magnetization, $H = H' - NI$.

Shuddemagen says: The demagnetizing factor is not a constant, falling for highest values of I to about 1/7 the value when unsaturated; for values of B ($= H + 4\pi I$) less than 10000, N is approximately constant; using a solenoid wound on an insulating tube, or a tube of split brass, the reversal method gives values for N which are considerably lower than those given by the step-by-step method; if the solenoid is wound on a thick brass tube, the two methods practically agree.

Ratio of Length to Diameter.	Values of $N \times 10^4$.						
	Ellipsoid.	Cylinder.					
		Uniform Magnetization.	Magnetometric Method (Mann).	Ballistic Step Method.			
				Dubois.	Shuddemagen for Range of Practical Constancy.		
				Diameter.			
				0.158 cm.	0.3175 cm.	1.111 cm.	1.905 cm.
5	7015	-	6800				
10	2549	630	2550	2160	-	-	1960
15	1350	280	1400	1206	-	-	1075
20	848	160	898	775	-	-	671
30	432	70	460	393	388	350	343
40	266	39	274	238	234	212	209
50	181	25	182	162	160	145	149
60	132	18	131	118	116	106	106
70	101	13	99	89	88		
80	80	9.8	78	69	69	66	63
90	65	7.8	63	55	56		
100	54	6.3	51.8	45	46	41	41
150	26	2.8	25.1	20	23	21	21
200	16	1.57	15.2	11	12.5	11	11
300	7.5	0.70	7.5	5.0			
400	4.5	0.39	-	2.8			

C. R. Mann, Physical Review, 3, p. 359; 1896.
H. DuBois, Wied. Ann. 7, p. 942; 1902.
C. L. B. Shuddemagen, Proc. Am. Acad. Arts and Sci. 43, p. 185, 1907 (Bibliography).

TABLE 302.

Shuddemagen also gives the following, where B is determined by the step method and $H = H' - KB$.

Ratio of Length to Diameter.	Values of $K \times 10^4$.	
	Diameter 0.3175 cm.	Diameter 1.1 to 2.0 cm.
15	-	85.2
20	-	53.3
25	-	36.6
30	30.9	27.3
40	18.6	16.6
50	12.7	11.6
60	9.25	8.45
80	5.5	5.05
100	3.66	3.26
150	1.83	1.67

TABLE 303.

COMPOSITION AND MAGNETIC

This table and Table 289 below are taken from a paper by Dr. Hopkinson * on the magnetic properties of iron and steel.
which is stated in the paper to have been 240. The maximum magnetization is not tabulated; but as stated in the
by 4π. " Coercive force " is the magnetizing force required to reduce the magnetization to zero. The "demag-
previous magnetization in the opposite direction to the " maximum induction " stated in the table. The "energy
which, however, was only found to agree roughly with the results of experiment.

No. of Test.	Description of specimen.	Temper.	Chemical analysis.					
			Total Carbon.	Manganese.	Sulphur.	Silicon.	Phosphorus.	Other substances.
1	Wrought iron	Annealed	-	-	-	-	-	-
2	Malleable cast iron	"	-	-	-	-	-	-
3	Gray cast iron	-	-	-	-	-	-	-
4	Bessemer steel	-	0.045	0.200	0.030	None.	0.040	-
5	Whitworth mild steel	Annealed	0.090	0.153	0.016	"	0.042	-
6	" "	"	0.320	0.438	0.017	0.042	0.035	-
7	" "	Oil-hardened	"	"	"	"	"	-
8	" "	Annealed	0.890	0.165	0.005	0.081	0.019	-
9	" "	Oil-hardened	"	"	"	"	"	-
10	Hadfield's manganese steel	-	1.005	12.360	0.038	0.204	0.070	-
11	Manganese steel	As forged	0.674	4.730	0.023	0.608	0.078	-
12	" "	Annealed	"	"	"	"	"	-
13	" "	Oil-hardened	"	"	"	"	"	-
14	" "	As forged	1.298	8.740	0.024	0.094	0.072	-
15	" "	Annealed	"	"	"	"	"	
16	" "	Oil-hardened	"	"	"	"	"	-
17	Silicon steel	As forged	0.685	0.694	"	3.438	0.123	-
18	" "	Annealed	"	"	"	"	"	-
19	" "	Oil-hardened	"	"	"	"	"	-
20	Chrome steel	As forged	0.532	0.393	0.020	0.220	0.041	0.621 Cr.
21	" "	Annealed	"	"	"	"	"	"
22	" "	Oil-hardened	"	"	"	"	"	"
23	" "	As forged	0.687	0.028	"	0.134	0.043	1.195 Cr.
24	" "	Annealed	"	"	"	"	"	"
25	" "	Oil-hardened	"	"	"	"	"	"
26	Tungsten steel	As forged	1.357	0.036	None.	0.043	0.047	4.649 W.
27	" "	Annealed	"	"	"	"	"	"
28	" "	Hardened in cold water	"	"	"	"	"	"
29	" "	Hardened in tepid water	"	"	"	"	"	"
30	" " (French)	Oil-hardened	0.511	0.625	None.	0.021	0.028	3.444 W.
31	" "	Very hard	0.855	0.312	-	0.151	0.089	2.353 W.
32	Gray cast iron	-	3.455	0.173	0.042	2.044	0.151	2.064 C.†
33	Mottled cast iron	-	2.581	0.610	0.105	1.476	0.435	1.477 C.†
34	White " "	-	2.036	0.386	0.467	0.764	0.458	-
35	Spiegeleisen	-	4.510	7.970	Trace.	0.502	0.128	-

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* Phil. Trans. Roy. Soc. vol. 176.

† Graphitic carbon.

PROPERTIES OF IRON AND STEEL.

The numbers in the columns headed "magnetic properties" give the results for the highest magnetizing force used, paper, it may be obtained by subtracting the magnetizing force (240) from the maximum induction and then dividing netizing force" is the magnetizing force which had to be applied in order to leave no residual magnetization after dissipated" was calculated from the formula:— Energy dissipated = coercive force × maximum induction ÷ π

No. of Test.	Description of specimen.	Temper.	Specific electrical resistance.	Magnetic properties.				Energy dissipated per cycle.
				Maximum induction.	Residual induction.	Coercive force.	Demagnetizive force.	
1	Wrought iron . . .	Annealed	.01378	18251	7248	2.30	–	13356
2	Malleable cast iron . .	"	.03254	12408	7479	8.80	–	34742
3	Gray cast iron . . .	–	.10560	10783	3928	3.80	–	13037
4	Bessemer steel . . .	–	.01050	18196	7860	2.96	–	17137
5	Whitworth mild steel .	Annealed	.01080	19840	7080	1.63	–	10289
6	" " .	"	.01446	18736	9840	6.73	–	40120
7	" " .	Oil-hardened	.01390	18796	11040	11.00	–	65786
8	" " .	Annealed	.01559	16120	10740	8.26	–	42366
9	" " .	Oil-hardened	.01695	16120	8736	19.38	–	99401
10	Hadfield's manganese steel .	–	.06554	310	–	–		–
11	Manganese steel . .	As forged	.05368	4623	2202	23.50	37.13	34567
12	" " . .	Annealed	.03928	10578	5848	33.86	46.10	113963
13	" " . .	Oil-hardened	.05556	4769	2158	27.64	40.29	41941
14	" " . .	As forged	.06993	747	–	–	–	–
15	" " . .	Annealed	.06316	1985	540	24.50	50.39	15474
16	" " . .	Oil-hardened	.07066	733	–	–	–	–
17	Silicon steel . . .	As forged	.06163	15148	11073	9.49	12.60	45740
18	" " . . .	Annealed	.06185	14701	8149	7.80	10.74	36485
19	" " . . .	Oil-hardened	.06195	14696	8084	12.75	17.14	59619
20	Chrome steel . . .	As forged	.02016	15778	9318	12.24	13.87	61439
21	" " . . .	Annealed	.01942	14848	7570	8.98	12.24	42425
22	" " . . .	Oil-hardened	.02708	13960	8595	38.15	48.45	169455
23	" " . . .	As forged	.01791	14680	7568	18.40	22.03	85944
24	" " . . .	Annealed	.01849	13233	6489	15.40	19.79	64842
25	" " . . .	Oil-hardened	.03035	12868	7891	40.80	56.70	167050
26	Tungsten steel . . .	As forged	.02249	15718	10144	15.71	17.75	78568
27	" " . . .	Annealed	.02250	16498	11008	15.30	16.93	80315
28	" " . . .	Hardened in cold water	.02274	–	–	–	–	–
29	" " . . .	Hardened in tepid water	.02249	15610	9482	30.10	34.70	149500
30	" " (French) .	Oil hardened	.03604	14480	8643	47.07	64.46	216864
31	" " . . .	Very hard	.04427	12133	6818	51.20	70.69	197660
32	Gray cast iron . . .	–	.11400	9148	3161	13.67	17.03	39789
33	Mottled cast iron . .	–	.06286	10546	5108	12.24	–	41072
34	White " " . .	–	.05661	9342	5554	12.24	20.40	36383
35	Spiegeleisen . . .	–	.10520	385	77	–	–	–

PERMEABILITY OF SOME OF THE SPECIMENS IN TABLE 303.

This table gives the induction and the permeability for different values of the magnetizing force of some of the specimens in Table 303. The specimen numbers refer to the same table. The numbers in this table have been taken from the curves given by Dr. Hopkinson, and may therefore be slightly in error; they are the mean values for rising and falling magnetizations.

Magnetizing force. *H*	Specimen 1 (iron).		Specimen 8 (annealed steel).		Specimen 9 (same as 8 tempered).		Specimen 3 (cast iron).	
	B	*μ*	*B*	*μ*	*B*	*μ*	*B*	*μ*
1	–	–	–	–	–	–	265	265
2	200	100	–	–	–	–	700	350
3	–	–	–	–	–	–	1625	542
5	10050	2010	1525	300	750	150	3000	600
10	12550	1255	9000	900	1650	165	5000	500
20	14550	727	11500	575	5875	294	6000	300
30	15200	507	12650	422	9875	329	6500	217
40	15800	395	13300	332	11600	290	7100	177
50	16000	320	13800	276	12000	240	7350	149
70	16360	234	14350	205	13400	191	7900	113
100	16800	168	14900	149	14500	145	8500	85
150	17400	116	15700	105	15800	105	9500	63
200	17950	90	16100	80	16100	80	10190	51

Tables 305–309 give the results of some experiments by Du Bois,[*] on the magnetic properties of iron, nickel, and cobalt under strong magnetizing forces. The experiments were made on ovoids of the metals 18 centimetres long and 0.6 centimetres diameter. The specimens were as follows: (1) Soft Swedish iron carefully annealed and having a density 7.82. (2) Hard English cast steel yellow tempered at 230° C.; density 7.78. (3) Hard drawn best nickel containing 99 % Ni with some SiO_2 and traces of Fe and Cu; density 8.82. (4) Cast cobalt giving the following composition on analysis: Co = 93.1, Ni = 5.8, Fe = 0.8, Cu = 0.2, Si = 0.1, and C = 0.3. The specimen was very brittle and broke in the lathe, and hence contained a surfaced joint held together by clamps during the experiment. Referring to the columns, *H*, *B*, and *μ* have the same meaning as in the other tables, *S* is the magnetic moment per gramme, and *I* the magnetic moment per cubic centimetre. *H* and *S* are taken from the curves published by Du Bois; the others have been calculated using the densities given.

TABLE 305.

MAGNETIC PROPERTIES OF SOFT IRON AT 0° AND 100° C.

Soft iron at 0° C.					Soft iron at 100° C.				
H	*S*	*I*	*B*	*μ*	*H*	*S*	*I*	*B*	*μ*
100	180.0	1408	17790	177.9	100	180.0	1402	17720	177.2
200	194.5	1521	19310	96.5	200	194.0	1511	19190	96.0
400	208.0	1627	20830	52.1	400	207.0	1613	20660	51.6
700	215.5	1685	21870	31.2	700	213.4	1663	21590	29.8
1000	218.0	1705	22420	22.4	1000	215.0	1674	22040	21.0
1200	218.5	1709	22670	18.9	1200	215.5	1679	22300	18.6

TABLE 306.

MAGNETIC PROPERTIES OF STEEL AT 0° AND 100° C.

Steel at 0° C.					Steel at 100° C.				
H	*S*	*I*	*B*	*μ*	*H*	*S*	*I*	*B*	*μ*
100	165.0	1283	16240	162.4	100	165.0	1278	16170	161.7
200	181.0	1408	17900	89.5	200	180.0	1395	17730	88.6
400	193.0	1500	19250	48.1	400	191.0	1480	19000	47.5
700	199.5	1552	20210	28.9	700	197.0	1527	19890	28.4
1000	203.5	1583	20900	20.9	1000	199.0	1543	20380	20.4
1200	205.0	1595	21240	17.7	1500	203.0	1573	21270	14.2
3750[†]	212.0	1650	24470	6.5	3000	205.5	1593	23020	7.7
					5000	208.0	1612	25260	5.1

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[*] "Phil. Mag." 5 series, vol. xxix.

[†] The results in this and the other tables for forces above 1200 were not obtained from the ovoids above referred to, but from a small piece of the metal provided with a polished mirror surface and placed, with its polished face normal to the lines of force, between the poles of a powerful electromagnet. The induction was then inferred from the rotation of the plane of a polarized ray of red light reflected normally from the surface. (See Kerr's "Constants," p. 292.)

MAGNETIC PROPERTIES OF METALS.

TABLE 307. — Cobalt at 100° C.

H	*S*	*I*	*B*	*μ*
200	106	848	10850	54.2
300	116	928	11960	39.9
500	127	1016	13260	26.5
700	131	1048	13870	19.8
1000	134	1076	14520	14.5
1500	138	1104	15380	10.3
2500	143	1144	16870	6.7
4000	145	1164	18630	4.7
6000	147	1176	20780	3.5
9000	149	1192	23980	2.6
At 0° C. this specimen gave the following results:				
7900	154	1232	23380	3.0

TABLE 308. — Nickel at 100° C.

H	*S*	*I*	*B*	*μ*
100	35.0	309	3980	39.8
200	43.0	380	4966	24.8
300	46.0	406	5399	18.0
500	50.0	441	6043	12.1
700	51.5	454	6409	9.1
1000	53.0	468	6875	6.9
1500	56.0	494	7707	5.1
2500	58.4	515	8973	3.6
4000	59.0	520	10540	2.6
6000	59.2	522	12561	2.1
9000	59.4	524	15585	1.7
12000	59.6	526	18606	1.5
At 0° C. this specimen gave the following results:				
12300	67.5	595	19782	1.6

TABLE 309. — Magnetite.

The following results are given by Du Bois * for a specimen of magnetite.

H	*I*	*B*	*μ*
500	325	8361	16.7
1000	345	9041	9.0
2000	350	10084	5.0
12000	350	20084	1.7

Professor Ewing has investigated the effects of very intense fields on the induction in iron and other metals.† The results show that the intensity of magnetization does not increase much in iron after the field has reached an intensity of 1000 c. g. s. units, the increase of induction above this being almost the same as if the iron were not there, that is to say, dB/dH is practically unity. For hard steels, and particularly manganese steels, much higher forces are required to produce saturation. Hadfield's manganese steel seems to have nearly constant susceptibility up to a magnetizing force of 10,000. The following tables, taken from Ewing's papers, illustrate the effects of strong fields on iron and steel. The results for nickel and cobalt do not differ greatly from those given above.

TABLE 310. — Lowmoor Wrought Iron.

H	*I*	*B*	*μ*
3080	1680	24130	7.83
6450	1740	28300	4.39
10450	1730	32250	3.09
13600	1720	35200	2.59
16390	1630	36810	2.25
18760	1680	39900	2.13
18980	1730	40730	2.15

TABLE 311. — Vicker's Tool Steel.

H	*I*	*B*	*μ*
6210	1530	25480	4.10
9970	1570	29650	2.97
12120	1550	31620	2.60
14660	1580	34550	2.36
15530	1610	35820	2.31

TABLE 312. — Hadfield's Manganese Steel.

H	*I*	*B*	*μ*
1930	55	2620	1.36
2380	84	3430	1.44
3350	84	4400	1.31
5920	111	7310	1.24
6620	187	8970	1.35
7890	191	10290	1.30
8390	263	11690	1.39
9810	396	14790	1.51

TABLE 313. — Saturation Values for Steels of Different Kinds.

		H	*I*	*B*	*μ*
1	Bessemer steel containing about 0.4 per cent carbon . . .	17600	1770	39880	2.27
2	Siemens-Marten steel containing about 0.5 per cent carbon	18000	1660	38860	2.16
3	Crucible steel for making chisels, containing about 0.6 per cent carbon	19470	1480	38010	1.95
4	Finer quality of 3 containing about 0.8 per cent carbon . .	18330	1580	38190	2.08
5	Crucible steel containing 1 per cent carbon	19620	1440	37690	1.92
6	Whitworth's fluid-compressed steel	18700	1590	38710	2.07

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* "Phil. Mag." 5 series, vol. xxix.

† "Phil. Trans. Roy. Soc." 1885 and 1889.

TABLE 314.—MAGNETIC PROPERTIES OF IRON IN VERY WEAK FIELDS.

The effect of very small magnetizing forces has been studied by C. Baur* and by Lord Rayleigh.† The following short table is taken from Baur's paper, and is taken by him to indicate that the susceptibility is finite for zero values of H and for a finite range increases in simple proportion to H. He gives the formula $k = 15 + 100 H$, or $I = 15 H + 100 H^2$. The experiments were made on an annealed ring of round bar 1.013 cms. radius, the ring having a radius of 9.432 cms. Lord Rayleigh's results for an iron wire not annealed give $k = 6.4 + 5.1 H$, or $I = 6.4 H + 5.1 H^2$. The forces were reduced as low as 0.00004 c. g. s., the relation of k to H remaining constant.

First experiment.			Second experiment.	
H	k	I	H	k
.01580	16.46	2.63	.0130	15.50
.03081	17.65	5.47	.0847	18.38
.07083	23.00	16.33	.0946	20.49
.13188	28.90	38.15	.1864	25.07
.23011	39.81	91.56	.2903	32.40
.38422	58.56	224.87	.3397	35.20

TABLES 315, 316.—DISSIPATION OF ENERGY IN CYCLIC MAGNETIZATION OF MAGNETIC SUBSTANCES.

When a piece of iron or other magnetic metal is made to pass through a closed cycle of magnetization dissipation of energy results. Let us suppose the iron to pass from zero magnetization to strong magnetization in one direction and then gradually back through zero to strong magnetization in the other direction and thence back to zero, and this operation to be repeated several times. The iron will be found to assume the same magnetization when the same magnetizing force is reached from the same direction of change, but not when it is reached from the other direction. This has been long known, and is particularly well illustrated in the permanency of hard steel magnets. That this fact involves a dissipation of energy which can be calculated from the open loop formed by the curves giving the relation of magnetization to magnetizing force was pointed out by Warburg‡ in 1881, reference being made to experiments of Thomson, § where such curves are illustrated for magnetism, and to E. Cohn, ‖ where similar curves are given for thermo-electricity. The results of a number of experiments and calculations of the energy dissipated are given by Warburg. The subject was investigated about the same time by Ewing, who published results somewhat later. ¶ Extensive investigations have since been made by a number of investigators.

TABLE 315.— Soft Iron Wire.

(From Ewing's 1885 paper.)

Total induction per sq. cm. B	Dissipation of energy in ergs per cu. cm.	Horse-power wasted per ton at 100 cycles per sec.
2000	420	0.74
3000	800	1.41
4000	1230	2.18
5000	1700	3.01
6000	2200	3.89
7000	2760	4.88
8000	3450	6.10
9000	4200	7.43
10000	5000	8.84
11000	5820	10.30
12000	6720	11.89
13000	7650	13.53
14000	8650	15.30
15000	9670	17.10

TABLE 316. — Cable Transformers.

This table gives the results obtained by Alexander Siemens with one of Siemens' cable transformers. The transformer core consisted of 900 soft iron wires 1 mm. diameter and 6 metres long.** The dissipation of energy in watts is for 100 complete cycles per second.

Mean maximum induction density in core. B	Total observed dissipation of energy in the core in watts per 112 lbs.	Calculated eddy current loss in watts per 112 lbs.	Hysteresis loss of energy in watts per 112 lbs.	Hysteresis loss of energy in ergs per cu. cm. per cycle.
1000	43.2	4	39.2	602
2000	96.2	16	80.2	1231
3000	158.0	36	122.0	1874
4000	231.2	64	167.2	2566
5000	309.5	100	209.5	3217
6000	390.1	144	246.1	3779

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* "Wied. Ann." vol. xi.

‡ "Wied. Ann." vol. xiii. p. 141.

‖ "Wied. Ann." vol. 6.

† "Phil. Mag." vol. xxiii.

§ "Phil. Trans. Roy. Soc." vol. 175.

¶ "Proc. Roy. Soc." 1882, and "Trans. Roy. Soc." 1885.

** "Proc. Inst. of Elect. Eng." Lond., 1892.

TABLE 317.

DISSIPATION OF ENERGY IN THE CYCLIC MAGNETIZATION OF VARIOUS SUBSTANCES.

C. P. Steinmetz concludes from his experiments* that the dissipation of energy due to hysteresis in magnetic metals can be expressed by the formula $e = aB^{1.6}$, where e is the energy dissipated and a a constant. He also concludes that the dissipation is the same for the same range of induction, no matter what the absolute value of the terminal inductions may be. His experiments show this to be nearly true when the induction does not exceed ± 15000 c. g. s. units per sq. cm. It is possible that, if metallic induction only be taken, this may be true up to saturation; but it is not likely to be found to hold for total inductions much above the saturation value of the metal. The law of variation of dissipation with induction range in the cycle, stated in the above formula, is also subject to verification.†

Values of Constant *a*.

The following table gives the values of the constant a as found by Steinmetz for a number of different specimens. The data are taken from his second paper.

Number of specimen.	Kind of material.	Description of specimen.	Value of a.
1	Iron	Norway iron	.00227
2	"	Wrought bar	.00326
3	"	Commercial ferrotype plate	.00548
4	"	Annealed " "	.00458
5	"	Thin tin plate	.00286
6	"	Medium thickness tin plate	.00425
7	Steel	Soft galvanized wire	.00349
8	"	Annealed cast steel	.00848
9	"	Soft annealed cast steel	.00457
10	"	Very soft annealed cast steel	.00318
11	"	Same as 8 tempered in cold water	.02792
12	"	Tool steel glass hard tempered in water	.07476
13	"	" " tempered in oil	.02670
14	"	" " annealed	.01899
15	"	Same as 12, 13, and 14, after having been subjected to an alternating m. m. f. of from 4000 to 6000 ampere turns for demagnetization	.06130
16	"		.02700
17	"		.01445
18	Cast iron	Gray cast iron	.01300
19	" "	" " " containing ⅛ % aluminium	.01365
20	" "	" " " " ½ % "	.01459
21	Magnetite	A square rod 6 sq. cms. section and 6.5 cms. long, from the Tilly Foster mines, Brewsters, Putnam County, New York, stated to be a very pure sample	.02348
22	Nickel	Soft wire	.0122
23	"	Annealed wire, calculated by Steinmetz from Ewing's experiments	.0156
24	"	Hardened, also from Ewing's experiments	.0385
25	Cobalt	Rod containing about 2 % of iron, also calculated from Ewing's experiments by Steinmetz	.0120
26	Iron filings	Consisted of thin needle-like chips obtained by milling grooves about 8 mm. wide across a pile of thin sheets clamped together. About 30 % by volume of the specimen was iron.	
		1st experiment, continuous cyclic variation of m. m. f. 180 cycles per second	.0457
		2d experiment, 114 cycles per second	.0396
		3d " 79–91 cycles per second	.0373

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* "Trans. Am. Inst. Elect. Eng." January and September, 1892.

† See T. Gray, "Proc. Roy. Soc." vol. lvi.

TABLE 318.

ENERGY LOSSES IN TRANSFORMER STEELS.

Determined by the wattmeter method.

Loss per cycle per $cc = AB^x + bnB^y$, where B = flux density in gausses and n = frequency in cycles per second. x shows the variation of hysteresis with B between 5000 and 10000 gausses, and y the same for eddy currents.

Designation.	Thickness. cm.	Ergs per Gramme per Cycle.				x	y	a	Watts per Pound at 60 Cycles and 10000 Gausses.		
		10000 Gausses.		5000 Gausses.					Eddy Current Loss for Gage No. 29.‡	Hysteresis.	Total.
		Hysteresis.	Eddy Currents at 60~	Hysteresis.	Eddy Currents at 60~						
Unannealed											
A	0.0399	1599	186	562	46	1.51	2.02	0.00490	0.41	4.35	4.76
B	.0326	1156	134	384	36	1.59	1.89	.00358	0.44	3.14	3.58
C	.0422	1032	242	356	70	1.51	1.79	.00319	0.47	2.81	3.28
D	.0381	1009	184	353	48	1.52	1.94	.00312	0.44	2.74	3.18
Annealed											
E	.0476	735	236	246	58	1.58	2.02	.00227	0.36	2.00	2.36
F	.0280	666	100	220	27	1.60	1.88	.00206	0.44	1.81	2.25
G	.0394	563	210	193	54	1.54	1.96	.00174	0.47	1.53	2.00
H*	.0307	412	146	138.5	39	1.58	1.90	.00127	0.54	1.12	1.66
J	.0318	341	202	111.5	55	1.62	1.88	.00105	0.70	0.93	1.63
K*	.0282	394	124	130	32	1.61	1.90	.00122	0.54	1.07	1.61
L	.0346	381	184	125	50	1.61	1.88	.00118	0.535	1.035	1.57
B	.0338	354	200	116	57	1.61	1.81	.00110	0.61	0.96	1.57
M	.0335	372	178	127	46	1.55	1.95	.00115	0.55	1.01	1.56
N	.0340	321	210	105	56	1.62	1.90	.00099	0.63	0.87	1.50
P	.0437	334	184	107	50	1.64	1.88	.00103	0.34	0.91	1.25
Silicon steels											
Q†	.0361	303	54	98	15	1.63	–	.00094	0.14	0.825	0.965
R	.0315	288	42	93	11	1.64	–	.00089	0.15	0.78	0.93
S	.0452	278	72	90	18	1.63	–	.00086	0.12	0.755	0.875
T	.0338	250	60	78	18	1.68	–	.00077	0.18	0.68	0.86
U	.0346	270	42	86	12	1.66	–	.00084	0.12	0.735	0.855
V*	.0310	251.5	47	79	13	1.68	–	.00078	0.17	0.685	0.855
W*	.0305	197	43	62.3	12.4	1.67	–	.00061	0.16	0.535	0.695
X	.0430	200	65	64.2	16.6	1.65	–	.00062	0.12	0.545	0.665

* German. † English.

‡ In order to make a fair comparison, the eddy current loss has been computed for a thickness of 0.0357 cm. (Gage No. 29), assuming the loss proportional to the thickness.

Lloyd and Fisher, Bull. Bur. Standards, 5, p. 453; 1909.

TABLE 319.

MAGNETO-OPTIC ROTATION.

Faraday discovered that, when a piece of heavy glass is placed in magnetic field and a beam of plane polarized light passed through it in a direction parallel to the lines of magnetic force, the plane of polarization of the beam is rotated. This was subsequently found to be the case with a large number of substances, but the amount of the rotation was found to depend on the kind of matter and its physical condition, and on the strength of the magnetic field and the wave-length of the polarized light. Verdet's experiments agree fairly well with the formula —

$$\theta = clH\left(r - \lambda\frac{dr}{d\lambda}\right)\frac{r^2}{\lambda^2},$$

where c is a constant depending on the substance used, l the length of the path through the substance, H the intensity of the component of the magnetic field in the direction of the path of the beam, r the index of refraction, and λ the wave-length of the light in air. If H be different, at different parts of the path, lH is to be taken as the integral of the variation of magnetic potential between the two ends of the medium. Calling this difference of potential v, we may write $\theta = Av$, where A is constant for the same substance, kept under the same physical conditions, when the one kind of light is used. The constant A has been called "Verdet's constant,"[*] and a number of values of it are given in Tables 303–310. For variation with temperature the following formula is given by Bichat: —

$$R = R_0\,(1 - 0.00104t - 0.000014t^2),$$

which has been used to reduce some of the results given in the table to the temperature corresponding to a given measured density. For change of wave-length the following approximate formula, given by Verdet and Becquerel, may be used: —

$$\frac{\theta_1}{\theta_2} = \frac{\mu_1^2(\mu_1^2 - 1)\lambda_2^2}{\mu_2^2(\mu_2^2 - 1)\lambda_1^2},$$

where μ is index of refraction and λ wave-length of light.

A large number of measurements of what has been called molecular rotation have been made, particularly for organic substances. These numbers are not given in the table, but numbers proportional to molecular rotation may be derived from Verdet's constant by multiplying in the ratio of the molecular weight to the density. The densities and chemical formulæ are given in the table. In the case of solutions, it has been usual to assume that the total rotation is simply the algebraic sum of the rotations which would be given by the solvent and dissolved substance, or substances, separately; and hence that determinations of the rotary power of the solvent medium and of the solution enable the rotary power of the dissolved substance to be calculated. Experiments by Quincke and others do not support this view, as very different results are obtained from different degrees of saturation and from different solvent media. No results thus calculated have been given in the table, but the qualitative result, as to the sign of the rotation produced by a salt, may be inferred from the table. For example, if a solution of a salt in water gives Verdet's constant less than 0.0130 at 20° C., Verdet's constant for the salt is negative.

The table has been for the most part compiled from the experiments of Verdet,[†] H. Becquerel,[‡] Quincke,[§] Koepsel,[||] Arons,[¶] Kundt,[**] Jahn,[††] Schönrock,[‡‡] Gordon,[§§] Rayleigh and Sidgewick,[||||] Perkin,[¶¶] Bichat.[***]

As a basis for calculation, Verdet's constant for carbon disulphide and the sodium line D has been taken as 0.0420 and for water as 0.0130 at 20° C.

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[*] The constancy of this quantity has been verified through a wide range of variation of magnetic field by H. E. J. G. Du Bois (Wied. Ann. vol. 35).

[†] "Ann. de Chim. et de Phys." [3] vol. 52.

[‡] "Ann. de Chim. et de Phys." [5] vol. 12; "C. R." vols. 90 and 100.

[§] "Wied. Ann." vol. 24.

[||] "Wied. Ann." vol. 26.

[¶] "Wied. Ann." vol. 24.

[**] "Wied. Ann." vols. 23 and 27.

[††] "Wied. Ann." vol. 43.

[‡‡] "Zeits. für Phys. Chem." vol. 11.

[§§] "Proc. Roy. Soc." 1883.

[||||] "Phil. Trans. R. S." 1885.

[¶¶] "Jour. Chem. Soc." vols. 8 and 12.

[***] "Jour. de Phys." vols. 8 and 9.

TABLE 320.

MAGNETO-OPTIC ROTATION.

Solids.

Substance.	Chemical formula.	Density or grammes per c. c.	Kind of light.	Verdet's constant in minutes.	Temp. C.	Authority.
Amber	–	–	D	0.0095	18–20°	Quincke.
Blende	ZnS	–	"	0.2234	15	Becquerel.
Diamond	C	–	"	0.0127	"	"
Fluor spar	$CaFl_2$	–	"	0.0087	"	"
Glass:						
Crown	–	–	"	0.0203	"	"
Faraday A	–	5.458	"	0.0782	18–20	Quincke.
" B	–	4.284	"	0.0649	"	"
Flint	–	–	"	0.0420	"	"
"	–	–	"	0.0325	15	Becquerel.
"	–	–	"	0.0416	"	"
" dense	–	–	"	0.0576	"	"
" "	–	–	"	0.0647	"	"
Plate	–	–	"	0.0406	18–20	Quincke.
Lead borate	PbB_2O_4	–	"	0.0600	15	Becquerel.
Quartz (perpendicular to axis)	–	–	"	0.0172	18–20	Quincke.
Rock salt	NaCl	–	"	0.0355	15	Becquerel.
Selenium	Se	–	B	0.4625	"	"
Sodium borate	$Na_2B_4O_7$	–	D	0.0170	"	"
Spinel (colored by chrome) .	–	–	"	0.0209	"	"
Sylvine	KCl	–	"	0.0283	"	"
Ziqueline (suboxide of copper)	Cu_2O	–	B	0.5908	"	"

TABLE 321.

MAGNETO-OPTIC ROTATION.

Liquids.

Substance.	Chemical formula.	Density in grammes per c. c.	Kind of light.	Verdet's constant in minutes.	Temp. C.	Authority.
Acetone	C_3H_6O	0.7947	D	0.0113	20	Jahn.
"	"	0.7957	"	0.0115	15	Perkin.
"	"	0.7947	"	0.0114	16	Schönrock.
Acids: (see also solutions in water)						
Acetic	$C_2H_4O_2$	1.0561	"	0.0105	21	Perkin.
Butyric	$C_4H_8O_2$	0.9663	"	0.0116	15	"
Formic	CH_2O_2	1.2273	"	0.0105	15	"
Hydrochloric	HCl	1.2072	"	0.0224	15	"
"	"	–	"	0.0206	15	Becquerel.
Hydrobromic	HBr	1.7859	"	0.0343	15	Perkin.
Hydroiodic	HI	1.9473	"	0.0513	15	"
Nitric	HNO_3	1.5190	"	0.0070	13	"
" (fuming)	"	–	"	0.0080	15	Becquerel.
Propionic	$C_3H_6O_2$	0.9975	"	0.0110	15	Perkin.
Sulphuric	H_2SO_4	–	"	0.0121	15	Becquerel.
Sulphurous	H_2SO_3	–	"	0.0153	15	"
Valeric	$C_5H_{10}O_2$	0.9438	"	0.0121	15	Perkin.
Alcohols:						
Amyl	$C_5H_{11}OH$	–	"	0.0131	15	Becquerel.
"	"	0.8107	"	0.0128	20	Jahn.
Butyl	C_4H_9OH	0.8021	"	0.0124	20	"
"	"	–	"	0.0124	15	Becquerel.
Ethyl	C_2H_5OH	0.7929	"	0.0107	18–20	Quincke.
"	"	0.7900	"	0.0112	20	Jahn.
"	"	0.7944	"	0.0114	15	Perkin.
"	"	0.7943	"	0.0113	16	Schönrock.
Methyl	CH_3OH	0.7915	"	0.0094	18–20	Quincke.
"	"	0.7920	"	0.0093	20	Jahn.
"	"	–	"	0.0106	15	Becquerel.
"	"	0.7966	"	0.0096	15	Perkin.
"	"	0.7903	"	0.0096	21.9	Schönrock.
Octyl	$C_8H_{17}OH$	0.8296	"	0.0134	15	Perkin.
Propyl	C_3H_7OH	0.8050	"	0.0120	20.8	Schönrock.
"	"	0.8082	"	0.0120	15.0	Perkin.
"	"	–	"	0.0118	15	Becquerel.
"	"	0.8042	"	0.0120	20	Jahn.
Benzene	C_6H_6	0.8786	"	0.0297	20	Jahn.
"	"	–	"	0.0268	15	Becquerel.
"	"	0.8718	"	0.0301	26.9	Schönrock.
Bromides:						
Bromoform	$CHBr_3$	2.9021	"	0.0317	15	Perkin.
Ethyl	C_2H_5Br	1.4486	"	0.0183	15	"
Ethylene	$C_2H_4Br_2$	2.1871	"	0.0268	15	"
"	"	2.1780	"	0.0269	20	Jahn.
Methyl	CH_3Br	1.7331	"	0.0205	0	Perkin.
Methylene	CH_2Br_2	2.4971	"	0.0276	15	"
Octyl	$C_8H_{17}Br$	1.1170	"	0.0164	15	"
Propyl	C_3H_7Br	1.3600	"	0.0180	15	"
Carbon disulphide	CS_2	1.2644	"	0.0441	18–20	Quincke.
" "	"	–	"	0.0434	0	Becquerel, 1885.
" "	"	–	"	0.0433	0	Gordon.
" "	"	–	"	0.0420	18	Rayleigh.
" "	"	–	"	0.0420	18	Koepsel.
" "	"	–	"	0.0439	0	Arons.

MAGNETO-OPTIC ROTATION.

Liquids.

Substance.	Chemical formula.	Density in grammes per c. c.	Kind of light.	Verdet's constant in minutes.	Temp. C.	Authority.
Chlorides:						
Amyl	CHCl	0.8740	D	0.0140	20	Jahn.
Arsenic	As	–	"	0.0422	15	Becquerel.
Carbon	C	–	"	0.0170	15	"
" bichloride	CCl_4	–	"	0.0321	15	"
Chloroform	$CHCl_3$	1.4823	"	0.0164	20	Jahn.
"	"	1.4990	"	0.0166	15	Perkin.
Ethyl	C_2H_5Cl	0.9169	"	0.0138	6	"
Ethylene	$C_2H_4Cl_2$	1.2589	"	0.0166	15	"
"	"	1.2561	"	0.0164	20	Jahn.
Methyl	CH_3Cl	–	"	0.0170	15	Becquerel.
Methylene	CH_2Cl_2	1.3361	"	0.0162	15	Perkin.
Octyl	$C_8H_{17}Cl$	0.8778	"	0.0141	15	"
Phosphorus protochloride	PCl_3	–	"	0.0275	15	Becquerel.
Propyl	C_3H_7Cl	0.8922	"	0.0135	15	Perkin.
Silicon	$SiCl_4$	–	"	0.0275	15	Becquerel.
Sulphur bichloride	S_2Cl_2	–	"	0.0393	15	"
Tin bichloride	$SnCl_4$	–	"	0.0151	15	"
Zinc bichloride	$ZnCl_2$	–	"	0.0437	15	"
Iodides:						
Ethyl	C_2H_5I	1.9417	"	0.0296	15	Perkin.
Methyl	CH_3I	2.2832	"	0.0336	15	"
Octyl	$C_8H_{17}I$	1.3395	"	0.0213	15	"
Propyl	C_3H_7I	1.7658	"	0.0271	15	"
Nitrates:						
Ethyl	$C_2H_5O.NO_2$	1.1149	"	0.0091	15	"
Ethylene (nitroglycol)	$C_2H_4(NO_3)_2$	1.4948	"	0.0088	15	"
Methyl	$CH_3O.NO_2$	1.2157	"	0.0078	15	"
Propyl	$C_3H_7O.NO_2$	1.0622	"	0.0100	15	"
Trinitrin (nitroglycerine)	$C_3H_5(NO_3)_3$	1.5996	"	0.0090	15	"
Nitro ethane	$C_2H_5NO_2$	1.0552	"	0.0095	15	"
Nitro methane	CH_3NO_2	1.1432	"	0.0084	15	"
Nitro propane	$C_3H_5NO_2$	1.0100	"	0.0102	15	"
Paraffins:						
Decane	$C_{10}H_{22}$	0.7218	"	0.0128	23.1	Schönrock.
Heptane	C_7H_{18}	0.6880	"	0.0125	15	Perkin.
Hexane	C_6H_{14}	0.6580	"	0.0122	22.1	Schönrock.
"	"	0.6743	"	0.0125	15	Perkin.
Octane	C_8H_{18}	0.7011	"	0.0128	23.1	Schönrock.
Pentane	C_5H_{12}	0.6196	"	0.0119	21.1	"
"	"	0.6332	"	0.0118	15	Perkin.
Phosphorus (melted)	P	–	"	0.1316	33	Becquerel.
Sulphur (melted)	S	–	"	0.0803	114	"
Toluene	C_7H_8	0.8581	"	0.0269	28.4	Schönrock.
"	"	–	"	0.0243	15	Becquerel.
Water	H_2O	0.9992	"	0.0130	15	"
"	"	0.9983	"	0.0131	18–20	Quincke.
"	"	0.9983	"	0.0132	20	Jahn.
Xylene	C_8H_{10}	–	"	0.0221	15	Becquerel.
"	"	0.8746	"	0.0263	27	Schönrock.

TABLE 322.

MAGNETO-OPTIC ROTATION.

Solutions of Acids and Salts in Water.

Substance.	Chemical formula.	Density, grammes per c. c.	Kind of light.	Verdet's constant in minutes.	Temp. C.	Authority.
Acetone	C_3H_6O	0.9715	D	0.0129	20°	Jahn.
Acids:						
Hydrobromic	HBr	1.7859	"	0.0343	15	Perkin.
"	"	1.6104	"	0.0304	"	"
"	"	1.3775	"	0.0244	"	"
"	"	1.2039	"	0.0194	"	"
"	"	1.1163	"	0.0168	"	"
Hydrochloric	HCl	1.2072	"	0.0225	"	"
"	"	1.1856	"	0.0219	"	"
"	"	1.1573	"	0.0204	"	"
"	"	1.1279	"	0.0193	"	"
"	"	1.0762	"	0.0168	"	"
"	"	1.0323	"	0.0150	20	Jahn.
"	"	1.0158	"	0.0140	"	"
Hydriodic	HI	1.9473	"	0.0513	"	Perkin.
"	"	1.9057	"	0.0499	"	"
"	"	1.8229	"	0.0468	"	"
"	"	1.7007	"	0.0421	"	"
"	"	1.4495	"	0.0323	"	"
"	"	1.2966	"	0.0258	"	"
"	"	1.1760	"	0.0205	"	"
Nitric	HNO_3	1.5190	"	0.0010	"	"
"	"	1.3560	"	0.0105	"	"
Sulphuric + $3H_2O$	H_2SO_4	–	"	0.0121	"	Becquerel.
Ammonia	NH_3	0.8918	"	0.0153	15	Perkin.
Bromides:						
Ammonium	NH_4Br	1.2805	"	0.0226	"	"
"	"	1.1576	"	0.0186	"	"
Barium	$BaBr_2$	1.5399	"	0.0215	20	Jahn.
"	"	1.2855	"	0.0176	"	"
Cadmium	$CdBr_2$	1.3291	"	0.0192	"	"
"	"	1.1608	"	0.0162	"	"
Calcium	$CaBr_2$	1.2491	"	0.0189	"	"
"	"	1.1337	"	0.0164	"	"
Potassium	KBr	1.1424	"	0.0163	"	"
"	"	1.0876	"	0.0151	"	"
Sodium	NaBr	1.1351	"	0.0165	"	"
"	"	1.0824	"	0.0152	"	"
Strontium	$SrBr_2$	1.2901	"	0.0186	"	"
"	"	1.1416	"	0.0159	"	"
Carbonate of potassium	K_2CO_3	1.1906	"	0.0140	20	"
" " sodium	Na_2CO_3	1.1006	"	0.0140	"	"
" " "	"	1.0564	"	0.0137	"	"
Chlorides:						
Ammonium (sal ammoniac)	NH_4Cl	1.0718	"	0.0178	15	Verdet.
Barium	$BaCl_2$	1.2897	"	0.0168	20	Jahn.
"	"	1.1338	"	0.0149	"	"
Cadmium	$CdCl_2$	1.3179	"	0.0185	"	"
"	"	1.2755	"	0.0179	"	"
"	"	1.1732	"	0.0160	"	"
"	"	1.1531	"	0.0157	"	"
Calcium	$CaCl_2$	1.1504	"	0.0165	"	"
"	"	1.0832	"	0.0152	"	"
"	"	1.1049	"	0.0157	16	Schönrock.
Copper	$CuCl_2$	1.5158	"	0.0221	15	Becquerel.
"	"	1.2789	"	0.0186	"	"
"	"	1.1330	"	0.0156	"	"

TABLE 322 (*continued*).

MAGNETO-OPTIC ROTATION.

Solutions of Acids and Salts in Water.

Substance.	Chemical formula.	Density, grammes per c. c.	Kind of light.	Verdet's constant in minutes.	Temp. C.	Authority.
Chlorides:						
Iron	$FeCl_2$	1.4331	D	0.0025	15°	Becquerel.
"	"	1.2141	"	0.0099	"	"
"	"	1.1093	"	0.0118	"	"
"	"	1.0548	"	0.0124	"	"
" (ferric) . .	Fe_2Cl_6	1.6933	"	—0.2026	"	"
"	"	1.5315	"	—0.1140	"	"
"	"	1.3230	"	—0.0348	"	"
"	"	1.1681	"	—0.0015	"	"
"	"	1.0864	"	0.0081	"	"
"	"	1.0445	"	0.0113	"	"
"	"	1.0232	"	0.0122	"	"
Lithium . . .	LiCl	1.0619	"	0.0145	20	Jahn.
"	"	1.0316	"	0.0143	"	"
Manganese . . .	$MnCl_2$	1.1966	"	0.0167	15	Becquerel.
"	"	1.0876	"	0.0150	"	"
Mercury . . .	$HgCl_2$	1.0381	"	0.0137	16	Schönrock.
"	"	1.0349	"	0.0137	"	"
Nickel	$NiCl_2$	1.4685	"	0.0270	15	Becquerel.
"	"	1.2432	"	0.0196	"	"
"	"	1.1233	"	0.0162	"	"
"	"	1.0690	"	0.0146	"	"
Potassium . . .	KCl	1.6000	"	0.0163	"	"
"	"	1.0732	"	0.0148	20	Jahn.
"	"	1.0418	"	0.0144	"	"
Sodium . . .	NaCl	1.2051	"	0.0180	15	Becquerel.
"	"	1.1058	"	0.0155	"	"
"	"	1.0546	"	0.0144	"	"
"	"	1.0817	"	0.0154	20	Jahn.
"	"	1.0418	"	0.0144	"	"
Strontium . . .	$SrCl_2$	1.1921	"	0.0162	"	"
"	"	1.0877	"	0.0146	"	"
Tin	$SnCl_2$	1.3280	"	0.0266	15	Verdet.
"	"	1.1637	"	0.0198	"	"
"	"	1.1112	"	0.0175	"	"
Zinc	$ZnCl_2$	1.2851	"	0.0196	"	"
"	"	1.1595	"	0.0161	"	"
Chromate of potassium .	K_2CrO_4	1.3598	"	0.0098	"	"
Bichromate of " .	$K_2Cr_2O_7$	1.0786	"	0.0126	"	"
Cyanide of mercury .	$Hy(CN)_2$	1.0638	"	0.0136	16	Schönrock.
" " " .	"	1.0425	"	0.0134	"	"
" " " .	"	1.0605	"	0.0135	"	"
Iodides:						
Ammonium . . .	NH_4I	1.5948	"	0.0396	15	Perkin.
"	"	1.5688	"	0.0386	"	"
"	"	1.5109	"	0.0358	"	"
"	"	1.2341	"	0.0235	"	"
Cadmium . . .	CdI	1.5156	"	0.0291	20	Jahn.
"	"	1.2770	"	0.0215	"	"
"	"	1.1521	"	0.0177	"	"
Potassium . . .	KI	1.6743	"	0.0338	15	Becquerel.
"	"	1.3398	"	0.0237	"	"
"	"	1.1705	"	0.0182	"	"
"	"	1.0871	"	0.0152	"	"
"	"	1.2380	"	0.0211	20	Jahn.
"	"	1.1245	"	0.0174	"	"
Sodium . . .	NaI	1.1939	"	0.0200	"	"
"	"	1.1191	"	0.0175	"	"

MAGNETO-OPTIC ROTATION.

TABLE 322. — Solutions of Acids and Salts in Water.

Substance.	Chemical formula.	Density, grammes per c. c.	Kind of light.	Verdet's constant in minutes.	Temp. C.	Authority.
Nitrates:						
Ammonium	NH_4NO_3	1.2803	D	0.0121	15	Perkin.
Potassium	KNO_3	1.0634	“	0.0130	20	Jahn.
Sodium	$NaNO_3$	1.1112	“	0.0131	“	“
Uranium	$U_2O_3.N_2O_5$	2.0267	“	0.0053	“	Becquerel.
“	“	1.7640	“	0.0078	“	“
“	“	1.3865	“	0.0105	“	“
“	“	1.1963	“	0.0115	“	“
Sulphates:						
Ammonium	$(NH_4)_2SO_4$	1.2286	“	0.0140	15	Perkin.
“ (acid)	$NH_4.HSO_4$	1.4417	“	0.0085	“	“
Barium	$BaSO_4$	1.1788	“	0.0134	20	Jahn.
“	“	1.0938	“	0.0133	“	“
Cadmium	$CdSO_4$	1.1762	“	0.0139	“	“
“	“	1.0890	“	0.0136	“	“
Lithium	Li_2SO_4	1.1762	“	0.0137	“	“
“	“	1.0942	“	0.0135	“	“
Manganese	$MnSO_4$	1.2441	“	0.0138	“	“
“	“	1.1416	“	0.0136	“	“
Potassium	K_2SO_4	1.0475	“	0.0133	“	“
Sodium	$NaSO_4$	1.0661	“	0.0135	“	“

TABLE 323. — Solutions of Salts in Alcohol.

Substance.	Chemical formula.	Density, grammes per c. c.	Kind of light.	Verdet's constant in minutes.	Temp. C.	Authority.
Cadmium bromide	$CdBr_2$	1.0446	D	0.0159	20	Jahn.
“ “	“	0.9420	“	0.0140	“	“
Calcium “	$CaBr_2$	0.9966	“	0.0154	“	“
“ “	“	0.8846	“	0.0130	“	“
Strontium “	$SrBr_2$	0.9636	“	0.0140	“	“
“ “	“	0.8814	“	0.0126	“	“
Cadmium chloride	$CdCl_2$	0.8303	“	0.0118	“	“
Strontium “	$SrCl_2$	0.8313	“	0.0118	“	“
“ “	“	0.8274	“	0.0117	“	“
Cadmium iodide	CdI_2	1.0988	“	0.0199	“	“
“ “	“	0.9484	“	0.0156	“	“

TABLE 324. — Solutions in Hydrochloric Acid.

Substance.	Chemical formula.	Density, grammes per c. c.	Kind of light.	Verdet's constant in minutes.	Temp. C.	Authority.
Antimony trichloride	$SbCl_3$	2.4755	D	0.0603	15	Becquerel.
“ “	“	1.8573	“	0.0449	“	“
“ “	“	1.5195	“	0.0347	“	“
“ “	“	1.3420	“	0.0277	“	“
Bismuth “	$BiCl_3$	2.0822	“	0.0396	“	“
“ “	“	1.6550	“	0.0359	“	“
“ “	“	1.4156	“	0.0350	“	“

TABLE 325. — Magneto-Optic Rotation.

Gases.

Substance.	Pressure.	Temp.	Verdet's constant in minutes.	Authority.
Atmospheric air	Atmospheric	Ordinary	6.83×10^{-6}	Becquerel.
Carbon dioxide	"	"	13.00 "	"
Carbon disulphide	74 cms.	70° C.	23.49 "	Bichat.
Ethylene	Atmospheric	Ordinary	34.48 "	Becquerel.
Nitrogen	"	"	6.92 "	"
Nitrous oxide	"	"	16.90 "	"
Oxygen	"	"	6.28 "	"
Sulphur dioxide	"	"	31.39 "	"
" "	246 cms.	20° C.	38.40 "	Bichat.

Du Bois discusses Kundt's results and gives additional experiments on nickel and cobalt. He shows that in the case of substances like iron, nickel, and cobalt which have a variable magnetic susceptibility the expression in Verdet's equation, which is constant for substances of constant susceptibility, requires to be divided by the susceptibility to obtain a constant. For this expression he proposes the name "Kundt's constant." These experiments of Kundt and Du Bois show that it is not the difference of magnetic potential between the two ends of the medium, but the product of the length of the medium and the induction per unit area, which controls the amount of rotation of the beam.

TABLE 326. — Verdet's and Kundt's Constants.

The following short table is quoted from Du Bois' paper. The quantities are stated in c. g. s. measure, circular measure (radians) being used in the expression of "Verdet's constant" and "Kundt's constant."

Name of substance.	Magnetic susceptibility.	Verdet's constant.		Wave-length of light in cms.	Kundt's constant.
		Number.	Authority.		
Cobalt	-	-	-	6.44×10^{-5}	3.99
Nickel	-	-	-	"	3.15
Iron	-	-	-	6.56 "	2.63
Oxygen: 1 atmo.	$+0.0126 \times 10^{-6}$	0.000179×10^{-6}	Becquerel.	5.89 "	0.014
Sulphur dioxide	—0.0751 "	0.302 "	"	"	—4.00
Water	—0.0694 "	0.377 "	Arons	"	—5.4
Nitric acid	—0.0633 "	0.356 "	Becquerel.	"	—5.6
Alcohol	—0.0566 "	0.330 "	De la Rive.	"	—5.8
Ether	—0.0541 "	0.315 "	"	"	—5.8
Arsenic chloride	—0.0876 "	1.222 "	Becquerel.	"	—14.9
Carbon disulphide	—0.0716 "	1.222 "	Rayleigh.	"	—17.1
Faraday's glass	—0.0982 "	1.738 "	Becquerel.	"	—17.7

TABLE 327.—Magnetic Susceptibility of Liquids and Gases.

The following table gives a comparison by Du Bois* of his own and some other determinations of the magnetic susceptibility of a few standard substances. Verdet's and Kundt's constants are in radians for the sodium line D.

Substance.	Verdet's constant.	Faraday's value $k \times 10^6$	Becquerel's value $k \times 10^6$	Wähner's value $k \times 10^6$
Water	3.77×10^{-6}	—0.69	—0.63	—0.536
Alcohol, C_2H_6O . . .	3.30 "	—0.57	—0.49	—0.388
Ether, $C_4H_{10}O$ . . .	3.15 "	—0.54	-	—0.360
Carbon disulphide . .	12.22 "	—0.72	—0.84	—0.465
Oxygen at 1 atmosphere .	0.00179 "	0.13	0.12	-
Air at 1 atmosphere . .	0.00194 "	0.024	0.025	-

Substance.	Quincke at 20° C.		Du Bois at 15° C.		
	Density.	$k \times 10^6$	Density.	$k \times 10^6$	Kundt's constant.
Water	0.9983	—0.815	0.9992	—0.837	—4.50
Alcohol, C_2H_6O . . .	0.7929	—0.660	0.7963	—0.694	—4.75
Ether, $C_4H_{10}O$ . . .	0.7152	—0.607	0.7250	—0.642	—4.91
Carbon disulphide . .	1.2644	—0.724	1.2692	—0.816	—14.97
Oxygen at 1 atmosphere .	-	-	0.00135	0.117	0.016
Air at 1 atmosphere . .	-	-	0.00123	0.024	0.081

TABLE 328.—Values of Kerr's Constant.†

Du Bois has shown that the rotation of the major axis of vibration of radiations normally reflected from a magnet is algebraically equal to the normal component of magnetization multiplied into a constant *K*. He calls this constant, *K*, Kerr's constant for the magnetized substance forming the magnet.

Color of light.	Spectrum line.	Wave-length in cms. $\times 10^6$	Kerr's constant in minutes per c. g. s. unit of magnetization.			
			Cobalt.	Nickel.	Iron.	Magnetite.
Red . . .	Li α	67.7	—0.0208	—0.0173	—0.0154	+0.0096
Red . . .	—	62.0	—0.0198	—0.0160	—0.0138	+0.0120
Yellow . . .	D	58.9	—0.0193	—0.0154	—0.0130	+0.0133
Green . . .	*b*	51.7	—0.0179	—0.0159	—0.0111	+0.0072
Blue . . .	F	48.6	—0.0180	—0.0163	—0.0101	+0.0026
Violet . . .	G	43.1	—0.0182	—0.0175	—0.0089	-

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* "Wied. Ann." vol. 35, p. 163.

† H. E. J. G. Du Bois, "Phil. Mag." vol. 29.

TABLE 329. — Variation of Resistance of Bismuth, with Temperature, in a Transverse Magnetic Field.

H	Proportional Values of Resistance.								
	−192°	−135°	−100°	−37°	0°	+18°	+60°	+100°	+183°
0	0.40	0.60	0.70	0.88	1.00	1.08	1.25	1.42	1.79
2000	1.16	0.87	0.86	0.96	1.08	1.11	1.26	1.43	1.80
4000	2.32	1.35	1.20	1.10	1.18	1.21	1.31	1.46	1.82
6000	4.00	2.06	1.60	1.29	1.30	1.32	1.39	1.51	1.85
8000	5.90	2.88	2.00	1.50	1.43	1.42	1.46	1.57	1.87
10000	8.60	3.80	2.43	1.72	1.57	1.54	1.54	1.62	1.89
12000	10.8	4.76	2.93	1.94	1.71	1.67	1.62	1.67	1.92
14000	12.9	5.82	3.50	2.16	1.87	1.80	1.70	1.73	1.94
16000	15.2	6.95	4.11	2.38	2.02	1.93	1.79	1.80	1.96
18000	17.5	8.15	4.76	2.60	2.18	2.06	1.88	1.87	1.99
20000	19.8	9.50	5.40	2.81	2.33	2.20	1.97	1.95	2.03
25000	25.5	13.3	7.30	3.50	2.73	2.52	2.22	2.10	2.09
30000	30.7	18.2	9.8	4.20	3.17	2.86	2.46	2.28	2.17
35000	35.5	20.35	12.2	4.95	3.62	3.25	2.69	2.45	2.25

TABLE 330. — Increase of Resistance of Nickel due to a Transverse Magnetic Field, expressed as % of Resistance at 0° and H = 0.

H	−190°	−75°	0°	+18°	+100°	+182°
0	+0	0	0	0	0	0
1000	+0.20	+0.23	+0.07	+0.07	+0.96	+0.04
2000	+0.17	+0.16	+0.03	+0.03	+0.72	−0.07
3000	0.00	−0.05	−0.34	−0.36	−0.14	−0.60
4000	−0.17	−0.15	−0.60	−0.72	−0.70	−1.15
6000	−0.19	−0.20	−0.70	−0.83	−1.02	−1.53
8000	−0.19	−0.23	−0.76	−0.90	−1.15	−1.66
10000	−0.18	−0.27	−0.82	−0.95	−1.23	−1.76
12000	−0.18	−0.30	−0.87	−1.00	−1.30	−1.85
14000	−0.18	−0.32	−0.91	−1.04	−1.37	−1.95
16000	−0.17	−0.35	−0.94	−1.09	−1.44	−2.05
18000	−0.17	−0.38	−0.98	−1.13	−1.51	−2.15
20000	−0.16	−0.41	−1.03	−1.17	−1.59	−2.25
25000	−0.14	−0.49	−1.12	−1.29	−1.76	−2.50
30000	−0.12	−0.56	−1.22	−1.40	−1.95	−2.73
35000	−0.10	−0.63	−1.32	−1.50	−2.13	−2.98

F. C. Blake, Ann. der Physik, 28, p. 449; 1909.

TABLE 331. — Change of Resistance of Various Metals in a Transverse Magnetic Field. Room Temperature.

Metal.	Field Strength in Gausses.	Per cent Increase.	Authority.
Nickel	10000	−1.2	Williams, Phil. Mag. 9, 1905.
"	"	−1.4	Barlow, Pr. Roy. Soc. 71, 1903.
"	6000	−1.0	Dagostino, Atti Ac. Linc. 17, 1908.
"	10000	−1.4	Grummach, Ann. der Phys. 22, 1906.
Cobalt	"	−0.53	"
Cadmium	"	+0.03	"
Zinc	"	+0.01	"
Copper	"	+0.004	"
Silver	"	+0.004	"
Gold	"	+0.003	"
Tin	"	+0.002	"
Palladium	"	+0.001	"
Platinum	"	+0.0005	"
Lead	"	+0.0004	"
Tantalum	"	+0.0003	"
Magnesium	6000	+0.01	Dagostino, *l. c.*
Manganin	"	+0.01	"
Tellurium	?	+0.02 to 0.34	Goldhammer, Wied Ann. 31, 1887.
Antimony	?	+0.02 to 0.16	"
Iron	Different specimens show very diverse results, usually an increase in weak fields, a decrease in strong.		Grummach, *l. c.* Barlow, *l. c.* Williams, *l. c.*
Nickel steel	Alloys behave similarly to iron.		Williams, *l. c.*

TABLE 332. — Transverse Galvanomagnetic and Thermomagnetic Effects.

Effects are considered positive when, the magnetic field being directed away from the observer, and the primary current of heat or electricity directed from left to right, the upper edge of the specimen has the higher potential or higher temperature.

E = difference of potential produced; T = difference of temperature produced; I = primary current; $\frac{dt}{dx}$ = primary temperature gradient; B = breadth, and D = thickness, of specimen; H = intensity of field. C. G. S. units.

Hall effect (Galvanomagnetic difference of Potential), $E = R\frac{HI}{D}$

Ettingshausen effect (" " " Temperature), $T = P\frac{HI}{D}$

Nernst effect (Thermomagnetic " " Potential), $E = QHB\frac{dt}{dx}$

Leduc effect (" " " Temperature), $T = SHB\frac{dt}{dx}$

Substance.	Values of R.	$P \times 10^6$.	$Q \times 10^6$.	$S \times 10^8$.
Tellurium	+400 to 800	+200	—360000	+400
Antimony	+ 0.9 " 0.22	+2	+9000 to 18000	+200
Steel	+.012 " 0.033	—0.07	—700 " 1700	+69
Hensler alloy	+.010 " 0.026		+1600 " 7000	
Iron	+.007 " 0.011	—0.06	—1000 " 1500	+39
Cobalt	+.0016 " 0.0046	+0.01	+1800 " 2240	+13
Zinc	–	–	—54 " 240	+13
Cadmium	+.00055			
Iridium	+.00040	–	up to —5.0	+5
Lead	+.00009	–	—5.0 (?)	
Tin	—.00003	–	—4.0 (?)	
Platinum	—.0002	–	–	—2
Copper	—.00052	–	—90 to 270	—18
German silver	—.00054			
Gold	—.00057 to .00071			
Constantine	—.0009			
Manganese	—.00093			
Palladium	—.0007 to .0012	–	+50 to 130	—3
Silver	—.0008 " .0015	–	—46 " 430	—41
Sodium	—.0023			
Magnesium	—.00094 to .0035			
Aluminum	—.00036 " .0037			
Nickel	—.0045 " .024	+0.04 to 0.19	+2000 " 9000	—45
Carbon	—.017	+5.	+100	
Bismuth	— up to 16.	+3 to 40	— up to 132000	—200

TABLE 333. — Variation of Hall Constant with the Temperature.

Bismuth.[1]						Antimony.[2]				
H	—182°	—90°	—23°	+11.5°	+100°	H	—186°	—79°	+21.5°	+58°
1000	62.2	28.0	17.0	13.3	7.28	1750	0.263	0.249	0.217	
2000	55.0	25.0	16.0	12.7	7.17	3960	0.252	0.243	0.211	
3000	49.7	22.9	15.1	12.1	7.06	6160	0.245	02.35	0.209	0.203
4000	45.8	21.5	14.3	11.5	6.95					
5000	42.6	20.2	13.6	11.0	6.84					
6000	40.1	18.9	12.9	10.6	6.72					

Bismuth.[3]									
H	+14.5°	+104°	125°	189°	212°	239°	259°	269°	270°
890	5.28	2.57	2.12	1.42	1.24	1.11	0.97	0.83	0.77*

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[1] Barlow, Ann. der Phys. 12, 1903.

[2] Everdingen, Comm. Phys. Lab. Leiden, 58.

[2] Traubenberg, Ann. der Phys. 17, 1905.

* Melting-point.

Both tables taken from Jahn, Jahrbuch der Radioactivität und Electronik, 5, p. 166; 1908, who has collected data of all observers and gives extensive bibliography.

APPENDIX I.

TABLES 334, 335.

THE SPECIFIC HEAT OF IRON AT HIGH TEMPERATURES.

Analysis of iron — (0.01 C, .02 Si, .03 S, .04 P, trace Mn).

TABLE 334. — Mean Specific Heat between 0° and T° Centigrade, S_0^T.

T	S_0^T	T	S_0^T
200°	0.1175	700°	0.1487
250	.1204	750	.1537
300	.1233	800	.1597
350	.1257	850	.1647
400	.1282	900	.1644
450	.1311	950	.1612
500	.1338	1000	.1557
550	.1361	1050	.1512
600	.1396	1100	.1534
650	.1440		

TABLE 335. — Total Heat between 0° and T° Centigrade, Q_0^T.

T	Q_0^T Pionchon's value recalculated.	Q_0^T Harker's value.
200	23.5	23.5
300	36.8	37.0
400	51.6	51.3
500	66.0	66.9
600	83.2	83.8
700	102.2	104.1
800	125.0	127.8
900	146.7	148.0
1000	166.0	155.7
1100	–	168.8

J. A. Harker, Proc. Physical Society, London, 19, p. 703; 1905.

Pionchon's data, based on experiments made many years ago, should be regarded only as corroborative of the more recent and careful experiments of Harker.

APPENDIX II.

DEFINITIONS OF UNITS.

ACTIVITY. Power or rate of doing work; unit, the watt.

AMPERE. Unit of electrical current. The international ampere, "which is one tenth of the unit of current of the C. G. S. system of electro-magnetic units, and which is represented sufficiently well for practical use by the unvarying current which, when passed through a solution of nitrate of silver in water, and in accordance with accompanying specifications" (*see* pages xxxiv and 251), "deposits silver at the rate of 0.001118 of a gramme per second."

The ampere = 1 coulomb per second = 1 volt through 1 ohm;

Amperes = volts/ohms = watts/volts = (watts/ohms)$^{\frac{1}{2}}$.

Amperes × volts = amperes^2 × ohms = watts.

ÅNGSTRÖM. Unit of wave-length = 10^{-10} metre.

ATMOSPHERE. Unit of pressure.

English normal = 14.7 pounds per sq. in. = 29.929 in. = 760.18 mm. Hg. 32° F.

French " = 760 mm. of Hg. 0° C. = 29.922 in. = 14.70 lbs. per sq. in.

BARAD. C. G. S. unit of pressure = 1 dyne per sq. cm.

BOUGIE DECIMALE. Photometric standard; *see* page 177.

BRITISH THERMAL UNIT. Heat required to raise one pound of water at its temperature of maximum density, 1° F. = 252 gramme-calories.

CALORY. Small calory = gramme-calory = therm = quantity of heat required to raise one gramme of water at its maximum density, one degree Centigrade.

Large calory = kilogramme-calory = 1000 small calories = one kilogramme of water raised one degree Centigrade at the temperature of maximum density.

For conversion factors *see* page 227.

CANDLE. Photometric standard, *see* page 177.

CARAT. The diamond carat = 3.168 grains = 0.2053 grammes.

The gold carat: pure gold is 24 carats; a carat is 1/24 part.

CARCEL. Photometric standard; *see* page 177.

CIRCULAR AREA. The square of the diameter = 1.2733 × true area.

True area = 0.785398 × circular area.

COULOMB. Unit of quantity. The international coulomb is the quantity of electricity transferred by a current of one international ampere in one second.

Coulombs = (volts-seconds)/ohms = amperes × seconds.

CUBIT = 18 inches.

DAY. Mean solar day = 1440 minutes = 86400 seconds = 1.0027379 sidereal day.

Sidereal day = 86164.10 mean solar seconds.

DIGIT. 3/4 inch; 1/12 the diameter of the sun or moon.

DYNE. C. G. S. unit of force = that force which acting for one second on one gramme produces a velocity of one centimetre per second.

= weight in grammes divided by the acceleration of gravity in cm. per sec.

ENERGY. *See* Erg.

ERG. C. G. S. unit of work and energy = one dyne acting through one centimetre.

For conversion factors *see* page 227.

FARAD. Unit of electrical capacity. The international farad is the capacity of a condenser charged to a potential of one international volt by one international coulomb of electricity.

The one-millionth part of a farad (microfarad) is more commonly used.

Farads = coulombs/volts.

FOOT–POUND. The work which will raise one pound one foot high.

For conversion factors *see* page 227.

FOOT-POUNDALS. The English unit of work = foot-pounds/g.

For conversion factors *see* page 227.

g. The acceleration produced by gravity.

GAUSS. A unit of intensity of magnetic field = 10^8 C. G. S. units.

GRAMME. *See* page 6.

GRAMME-CENTIMETRE. The gravitation unit of work = g. ergs.

For further conversion factors *see* page 227.

HEAT UNIT. *See* Calory.

HEAT OF THE ELECTRIC CURRENT generated in a metallic circuit without self-induction is proportional to the quantity of electricity which has passed in coulombs multiplied by the fall of potential in volts, or is equal to (coulombs × volts)/4.181 in small calories.

The heat in small or gramme-calories per second $= (\text{amperes}^2 \times \text{ohms})/4.181 = \text{volts}^2/(\text{ohms} \times 4.181) = (\text{volts} \times \text{amperes})/4.181 = \text{watts}/4.181$.

HEAT. Absolute zero of heat = −273° Centigrade, −459.4° Fahrenheit, −218.4° Reaumur.

HEFNER UNIT. Photometric standard; *see* page 177.

HENRY. Unit of induction. It is "the induction in a circuit when the electromotive force induced in this circuit is one international volt, while the inducing current varies at the rate of one ampere per second."

HORSE-POWER. The practical unit of power = 33,000 pounds raised one foot per minute.

JOULE. Unit of work = 10^7 ergs.

Joules $= (\text{volts}^2 \times \text{seconds})/\text{ohms} = \text{watts} \times \text{seconds} = \text{amperes}^2 \times \text{ohms} \times \text{sec.}$

For conversion factors *see* page 227.

JOULE'S EQUIVALENT. The mechanical equivalent of heat $= 4.181 \times 10^7$ ergs. *See* page 227.

KILODYNE. 1000 dynes. About 1 gramme.

LITRE. *See* page 6.

MEGABAR. Unit of pressure = 0.987 atmospheres.

MEGADYNE. One million dynes. About one kilogramme.

METRE. *See* page 6.

METRE CANDLE. The intensity lumination due to standard candle distant one metre.

METRET. An exponential subdivision of the metre. The ordinal number before the word metre denotes the power of ten serving as the divisor; e. g., a tenth-metret $= 10^{-10} = 1/10^{10}$ metre. The first metret is the decimetre, the second, the centimetre, etc.

MHO. The unit of electrical conductivity. It is the reciprocal of the ohm.

MICRO. A prefix indicating the millionth part.

MICROFARAD. One millionth of a farad, the ordinary measure of electrostatic capacity.

MICRON. (μ) = one millionth of a metre.

MIL. One thousandth of an inch.

MILE. *See* pages 5, 6.

MILE, NAUTICAL or GEOGRAPHICAL = 6080.204 feet.

MILLI-. A prefix denoting the thousandth part.

MONTH. The anomalistic month = time of revolution of the moon from one perigee to another = 27.55460 days.

The nodical month = draconitic month = time of revolution from a node to the same node again = 27.21222 days.

The sidereal month = the time of revolution referred to the stars = 27.32166 days (mean value), but varies by about three hours on account of the eccentricity of the orbit and "perturbations."

The synodic month = the revolution from one new moon to another = 29.5306 days (mean value) = the ordinary month. It varies by about 13 hours.

OHM. Unit of electrical resistance. The international ohm is based upon the ohm equal to 10^9 units of resistance of the C. G. S. system of electromagnetic units, and "is represented by the resistance offered to an unvarying electric current by a column of mercury, at the temperature of melting ice, 14.4521 grammes in mass, of a constant cross section and of the length of 106.3 centimetres."

International ohm = 1.01367 B. A. ohms = 1.06292 Siemens' ohms.

B. A. ohm = 0.98651 international ohms.

Siemens' ohm = 0.94080 international ohms. *See* page 261.

PENTANE CANDLE. Photometric standard. *See* page 177.

PI $= \pi =$ ratio of the circumference of a circle to the diameter = 3.14159265359.

POUNDAL. The British unit of force. The force which will in one second impart a velocity of one foot per second to a mass of one pound.

RADIAN $= 180°/\pi = 57.29578° = 57°\ 17'\ 45'' = 206625''$.

SECOHM. A unit of self-induction = 1 second × 1 ohm.

THERM = small calory = quantity of heat required to warm one gramme of water at its temperature of maximum density one degree Centigrade.

THERMAL UNIT, BRITISH = the quantity of heat required to warm one pound of water at its temperature of maximum density one degree Fahrenheit = 252 gramme-calories.

VOLT. The unit of electromotive force (E. M. F.). The international volt is "the electromotive force that, steadily applied to a conductor whose resistance is one international ohm, will produce a current of one international ampere, and which is represented sufficiently well for practical use by 1000/1434 of the electromotive force between the poles or electrodes of the voltaic cell known as Clark's cell, at a temperature of 15° C and prepared in the manner described in the accompanying specification." *See* pages xxxiv and 251.

VOLT-AMPERE. Equivalent to Watt.

WATT. The unit of electrical power = 10^7 units of power in the C. G. S. system. It is represented sufficiently well for practical use by the work done at the rate of one Joule per second.

Watts = volts × amperes = amperes^2 × ohms = volts^2/ohms.

For conversion factors *see* page 227.

Watts × seconds = Joules.

WEBER. A name formerly given to the coulomb.

YEAR. *See* page 108.

Anomalistic	year	=365	days,	6	hours,	13	minutes,	48 seconds.
Sidereal	"	=365	"	6	"	9	"	9.314 seconds.
Ordinary	"	=365	"	5	"	48	"	46+ "
Tropical	"	same as the ordinary year.						

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For the definitions of units, see Appendix.

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